Sec. 15

6 JUL 28 1961

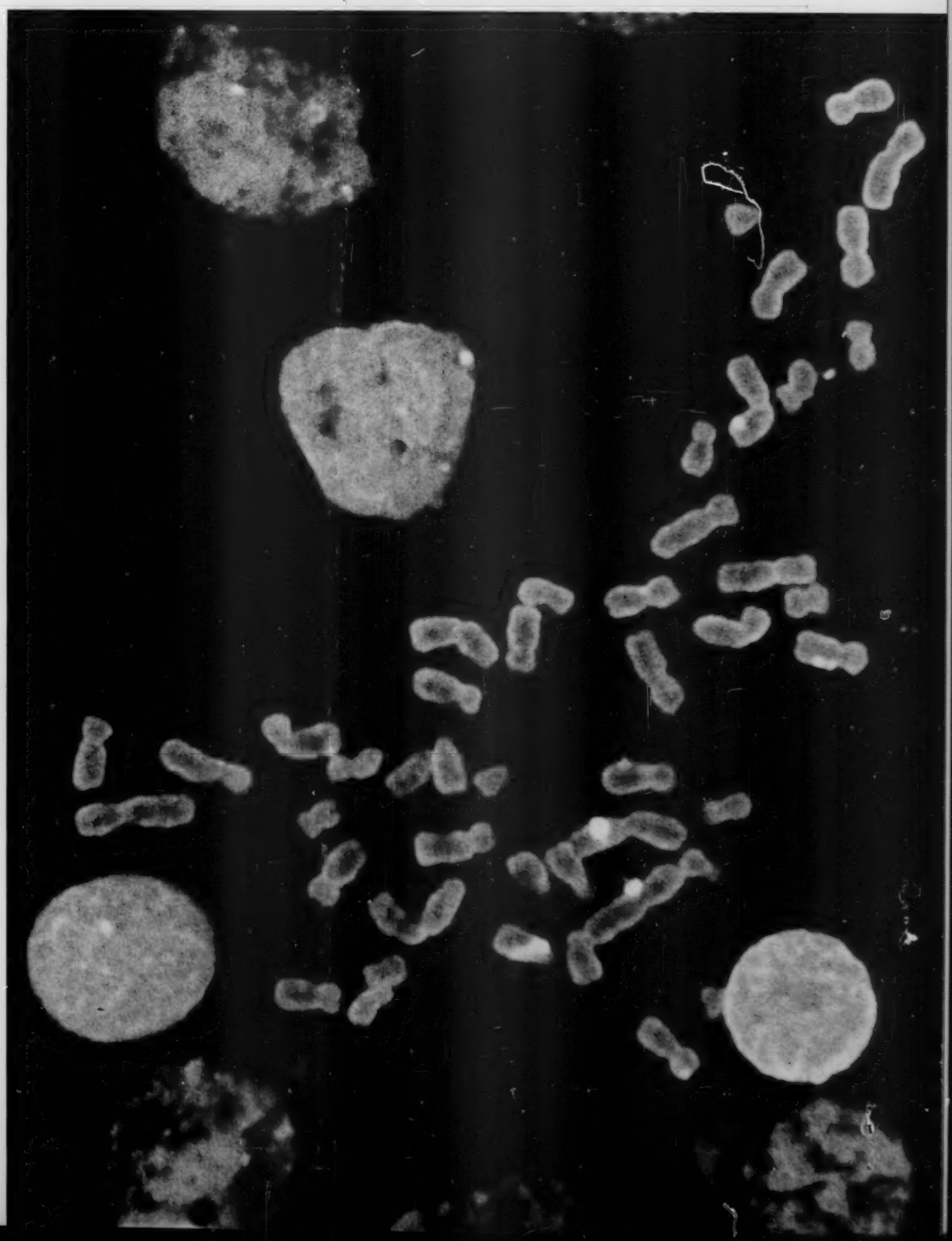
Com. Copy

SCIENCE

28 July 1961

Vol. 134, No. 3474

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



NOW—MORE SPEED, MORE FORCE

...to spin down samples faster

...to isolate smaller molecules

Those who use laboratory centrifugation to separate, concentrate, and isolate macromolecules now have at their command nearly 200,000 g's of centrifugal force in the rugged, easy-to-operate Model L Preparative Ultracentrifuge.

These higher forces are possible with an increase in the top speed of current-production Model L's from 40,000 to 50,000 rpm—and with development of a new, higher-speed angle rotor. The new rotor holds 100 ml in ten tubes, and at maximum speed generates 198,000 g at the outer tube edge—54,000 g more than previous Model L angle rotors.

Centrifugal separations thus become an even more powerful laboratory tool . . . work can be completed faster . . . even smaller proteins, viruses, and other molecules can be sedimented.

For more information on the 50,000 rpm Model L and the new Type 50 rotor, please write Beckman Instruments, Inc., Spinco Division, Stanford Industrial Park, Palo Alto, California, for Data File L-5.

Beckman® / **Spinco Division**
Beckman Instruments, Inc.

82-A

SCIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C. Second-class postage paid at Washington, D.C., and additional mailing office. Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢.

UNEQUALLED PERFORMANCE! Ronnie Robertson can spin faster on ice skates than anyone in the world. 420 rpm to be exact. So fast, military scientists have studied him for the biological effects of centrifugal force.

In refrigerated centrifuges IEC's HR-1 spins faster (18,500 rpm) while developing more gravities (41,320 x G) than ever before available in the standard price range. This gives you the dependable force that means faster, better separation under fully controlled temperature, hour after hour through the entire lab day.

You can increase your work potential with the HR-1 . . . send for Bulletin 0-61.

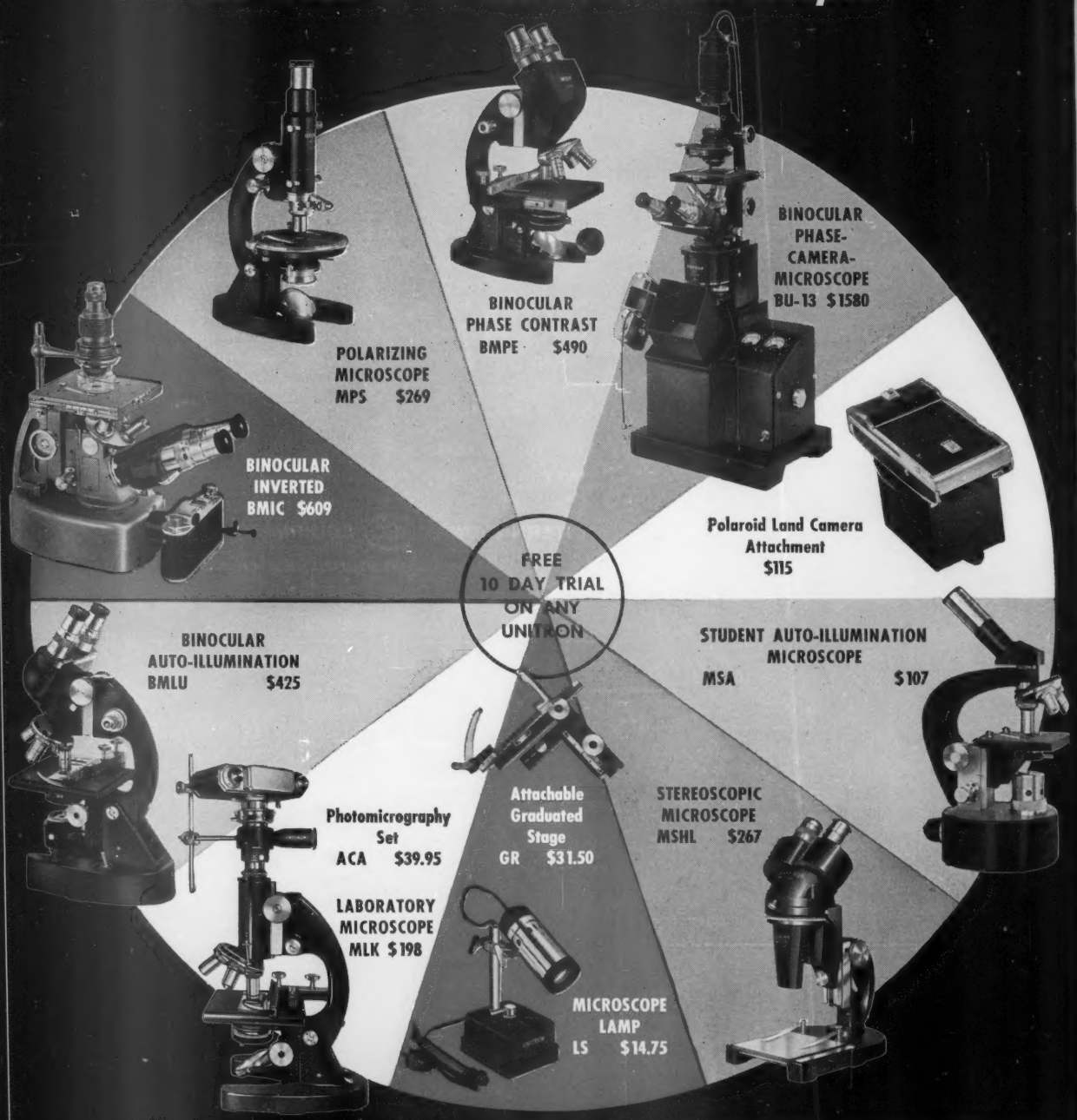
INTERNATIONAL IEC EQUIPMENT CO.

1284 SOLDIERS FIELD ROAD, BOSTON, MASS.

Model HR-1

World Champion Ronnie Robertson, star of the 22nd Edition of Ice Capades

In the Laboratory . . . where optical quality counts . . . the trend is to UNITRON Microscopes


POLARIZING MICROSCOPE MPS $269
BINOCULAR PHASE CONTRAST BMPE $490
BINOCULAR PHASE-CAMERA-MICROSCOPE BU-13 $1580
BINOCULAR INVERTED BMIC $609
Polaroid Land Camera Attachment $115
FREE 10 DAY TRIAL ON ANY UNITRON
BINOCULAR AUTO-ILLUMINATION BMLU $425
STUDENT AUTO-ILLUMINATION MICROSCOPE MSA $107
Photomicrography Set ACA $39.95
Attachable Graduated Stage GR $31.50
STEREOSCOPIC MICROSCOPE MSHL $267
LABORATORY MICROSCOPE MLK $198
MICROSCOPE LAMP LS $14.75

UNITRON offers an extensive line of Laboratory Microscopes & Accessories for Research, Industry and Education. Illustrated is a partial selection for biology, medicine, chemistry and related fields. UNITRON also has companion instruments for the metalworking industries.

Noted for optical quality . . . advanced optical and mechanical design . . . unique and convenient operational features . . . long wearing construction . . . attractive budget prices which include basic optics . . . these, together with years of proven instrument performance, are the reasons why . . .

THE TREND IS TO UNITRON!

UNITRON

INSTRUMENT COMPANY • MICROSCOPE SALES DIV.
66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS.

Please rush UNITRON's Microscope Catalog 4-R-4

Name_____

Company_____

Address_____

City_____ State_____

28 July 1961, Volume 134, Number 3474

SCIENCE

Editorial

Arms Control and Self Control 249

Articles

Patination of Cultural Flints: *V. J. Hurst* and *A. R. Kelly* 251
Flint artifacts can be dated by cortical changes in mineralogy and texture.

Infectious Nucleic Acids, a New Dimension in Virology: *R. M. Herriott* 256
Their release from infected tissues and resistance to antibodies may explain some anomalous conditions.

Financing Scientific Research in Australia: *S. Encel* 260
Federal funds and research agencies play a dominant role in the national research effort.

Arnold L. Gesell: "Behavior Has Shape": *L. B. Ames* 266

Science and the News

The School Bill: Notes on the Political Situation 268

Book Reviews

Space Travel Comes down to Earth: *J. B. Irwin* 272
Astronomy, the so-called impractical science, has become of intense immediate concern to John Q. Public.

Biology and Comparative Physiology of Birds, reviewed by *H. Friedmann*; other reviews 275

Reports

Anopheles hackeri, a Vector of *Plasmodium knowlesi* in Malaya: *R. H. Wharton* and *D. E. Eyles* 279

Suppression of Shoot Formation in Cultured Tobacco Cells by Gibberellic Acid: *T. Murashige* 280

Acid-Catalyzed Oxidation of Reduced Pyridine Nucleotides: *I. G. Fels* 280

L-Tyrosine Oxidase System in Tuber of Nutsedge: *R. D. Palmer* 281

Correlation of Nuclear Volume and DNA Content with Higher Plant Tolerance to Chronic Radiation: *A. H. Sparrow* and *J. P. Miksche* 282

Identification of a Cyanogenetic Growth-Inhibiting Substance in Extracts from Peach Flower Buds: *M. B. Jones* and *J. V. Enzie* 284

Reaction of Human Sera with Mammalian Chromosomes Shown by Fluorescent Antibody Technique: *R. S. Krooth* et al. 284

Possible Mode of Antidepressive Action of Imipramine: *L. Stein* and *J. Seifter* 286

Departments

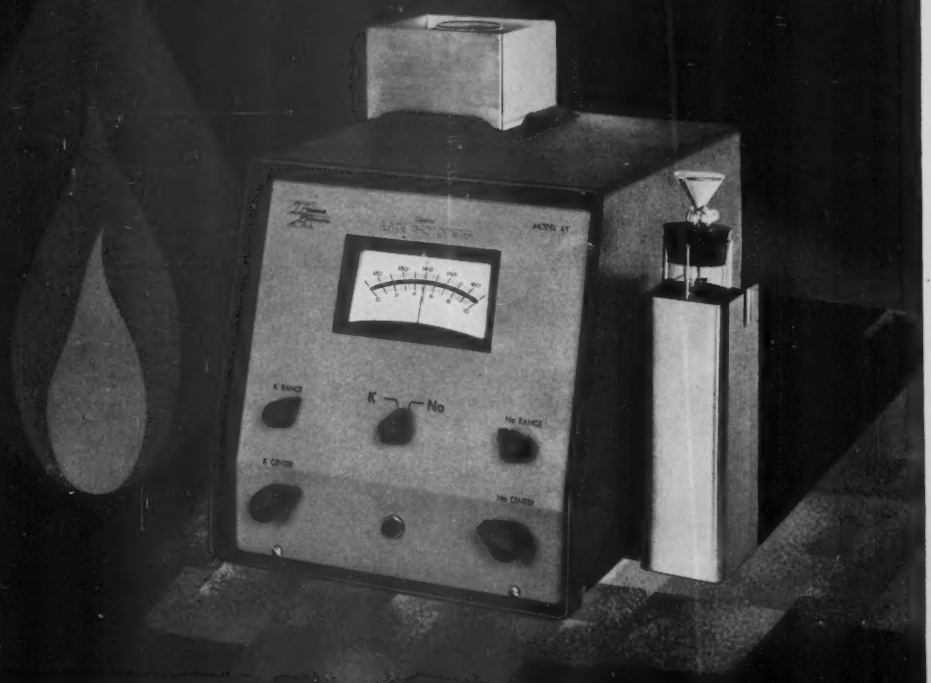
Marine Animal Sounds; Forthcoming Events 288

Cover

Fluorescence photomicrograph of human chromosomes from a peripheral blood culture. The preparation was treated with serum from a patient having lupus erythematosus and was subsequently stained with fluorescein-labeled horse antihuman globulin. The human serum containing antinuclear factors apparently reacted with the chromosomes. After the subsequent application of fluorescent antibody, the chromosomes could be seen as yellow, glowing structures when stimulated with ultraviolet light. Normal serum did not react with the chromosomes and did not stain with fluorescent antibody. All of the 23 pairs of chromosomes fluoresce. The resting nuclei also show fluorescence (about × 2700). See page 284. [R. S. Krooth, University of Rochester Medical Center, Rochester, New York]

Now–Determine Na and K Simultaneously

...in less than 20 seconds



NEW BAIRD-ATOMIC FLAME PHOTOMETER PROVIDES TWO DETERMINATIONS FROM JUST ONE DILUTION WITH ±0.5% REPRODUCIBILITY.

A single 0.05cc sample (diluted 1:200) – and a flick of a switch... that's all it takes to accurately determine Na and K concentrations with the Baird-Atomic Flame Photometer, Model KY. Tedious calculations, between-run cleanings and recalibrations are gone forever.

Its exclusive B/A Multilayer Filters provide a rejection factor of more than 99.9% at unwanted wavelengths making it more efficient than spectrophotometer-type instruments. Compact and portable, the B/A Model KY operates equally well on manufactured, natural or bottle gas. Because of its sealed air system and thorough shielding, readings are not affected by tobacco smoke, solvent fumes or other airborne contaminants.

Write today for more complete information... Engineers and scientists — investigate challenging opportunities with Baird-Atomic.

Only the Baird-Atomic Flame Photometer offers you the combined advantages of:

- **Instantaneous meq/liter readout**
- **Double beam instrument accuracy**
- **Simultaneous single-sample determinations**

B/A Flame Photometer Condensed Specifications. Metals Analyzed and Guaranteed Sensitivity (1% of full scale):

Metal	meq/l	mg%	ppm
Na	0.001	0.002	0.02
K	0.0025	0.001	0.01
Li	0.028	0.02	0.02

Reproducibility: ±0.5% av. Size: 15" x 17" x 16" Wgt.: 35 lbs.

BAIRD-ATOMIC, INC.

33 university road · cambridge 38, mass.

ADVANCED OPTICS AND ELECTRONICS... SERVING SCIENCE

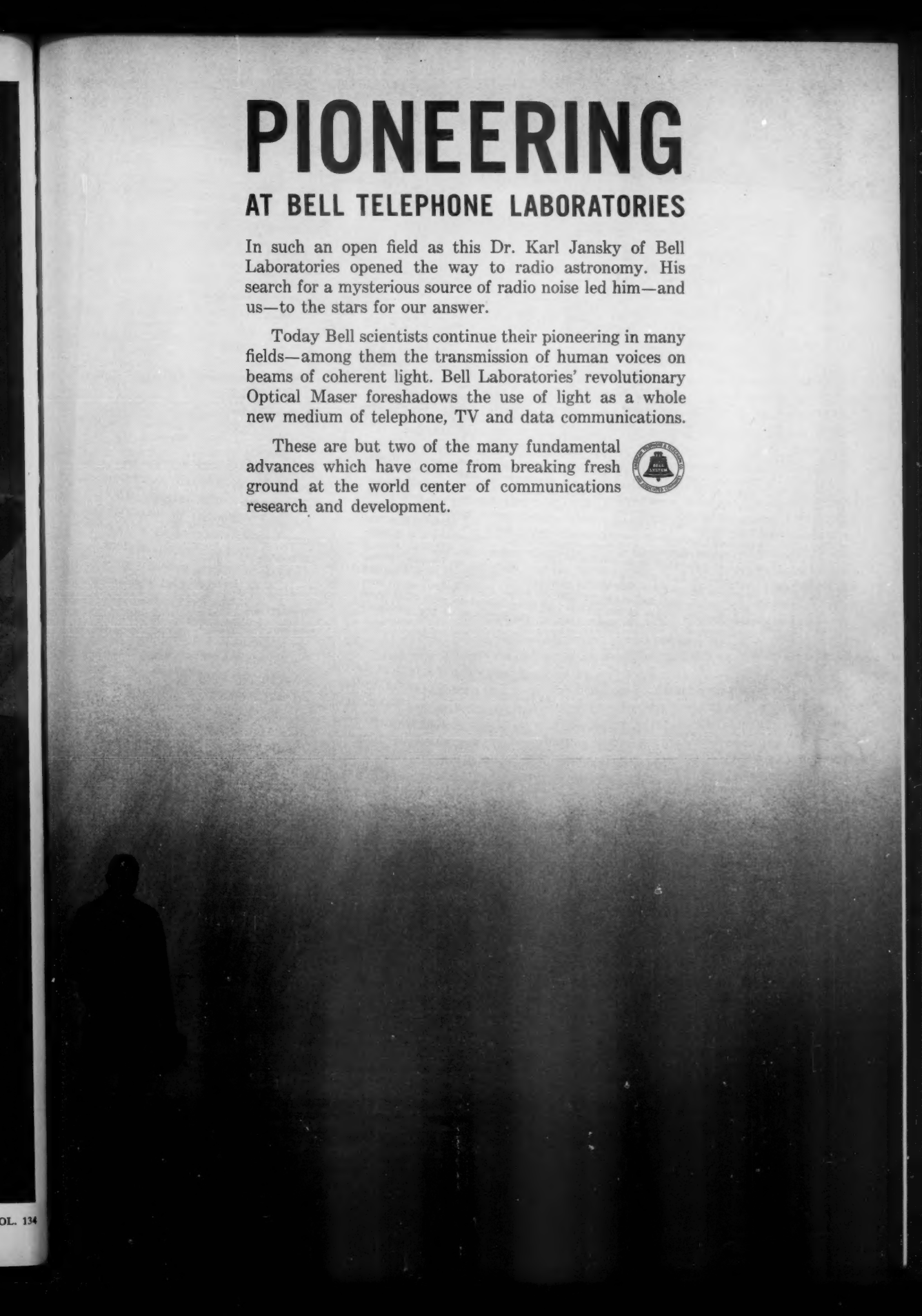
PIONEERING

AT BELL TELEPHONE LABORATORIES

In such an open field as this Dr. Karl Jansky of Bell Laboratories opened the way to radio astronomy. His search for a mysterious source of radio noise led him—and us—to the stars for our answer.

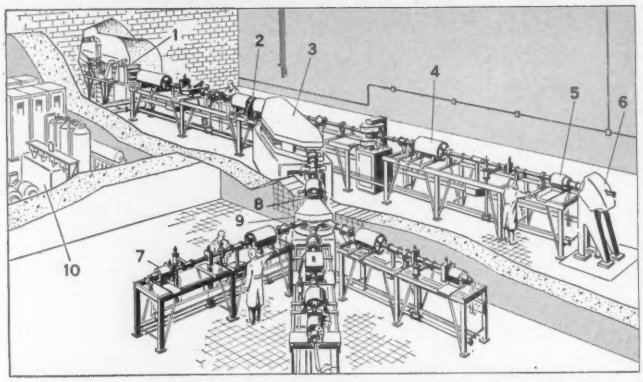
Today Bell scientists continue their pioneering in many fields—among them the transmission of human voices on beams of coherent light. Bell Laboratories' revolutionary Optical Maser foreshadows the use of light as a whole new medium of telephone, TV and data communications.

These are but two of the many fundamental advances which have come from breaking fresh ground at the world center of communications research and development.



High Voltage Engineering Corporation . . .

"CHARGED PARTICLES"



Typical high power electron beam analyzing and deflecting system for 10 to 80-Mev, 30 kw linac

1. Linac
2. Positron Target
3. Deflecting Magnet System and Energy-Defining Slits
4. Focusing Lens
5. Neutron Target
6. Terminating Magnet
7. Targets (3)
8. Monoenergetic Gamma Target
9. Switching Magnet
10. Equipment Room

The main features of this analyzing system are: (a) the beam can be delivered to any of three different experimental areas, focused to a small spot or spread out over a large area to facilitate target cooling; (b) net energy dispersion of the beam after deflection is negligible. This means that maximum beam of the desired energy is available because particles of varying energies move along the same center line into target regions; (c) in the deflecting magnet system there is a large energy dispersion at a collimator, which selects the required energy spectrum with a precision of 0.1 per cent or better; (d) the part of the electron beam discarded at this collimator or elsewhere in the system produces x-rays, the major portion of which are directed away from experimental areas; (e) the system can be converted to handle positrons produced in a shower target close to the entrance of the deflecting magnet system.

High Power Linacs

In a recent discussion of *High Energy Linacs,* we indicated that the power of the new accelerators, plus better energy resolution opens up intriguing possibilities for the experimental physicist. One of these possibilities involves production of a monoenergetic gamma-ray beam, with adjustable energy, heretofore just a dream.

Positron annihilation in flight in a thin target produces such a gamma-ray beam. The linac electron beam is used to produce positrons in a wide energy spectrum in a shower target. These particles are energy-analyzed in a deflecting magnet before they impinge upon the annihilation target. Energy selection of the gamma rays is accomplished by varying the magnetic field of the deflecting magnet. The conversion factor is small, so it is essential to have an intense electron beam. It is not essential, however, to have a high degree of beam-energy homogeneity.

An experiment in which beam-energy homogeneity is important is the spectroscopic study of inelastically-scattered electrons from nuclei. Magnetic spectrometers for this kind of experiment can be built with a resolution of better than 0.1 per cent, and the electron beam must be analyzed to this accuracy before it impinges upon the scattering target.

Hot Electron Beams

The high accuracy and power called for in these experiments requires considerable beam-handling ingenuity. The problems may be illustrated: A typical high-energy linac will put 45 kw of high-energy electrons on a one-half centimeter square — this equals 180 kw/cm², enough to vaporize any known material in a few seconds. To make such a system fail-safe requires precisely-protected beam slits and electron scattering devices, and specially cooled vacuum chambers, in addition to the analyzing and collimating equipment. The situation is complicated by an x-ray background which prohibits use of organic materials for coil insulation and vacuum gasketing.

The beam analyzing and deflecting system is an increasingly complex and important part of the linac experimental facility. An inadequate system will greatly reduce the accelerator's research utility. Fortunately, High Voltage Engineering has had years of experience designing and building extremely accurate, magnetic analyzing systems to guaranteed specifications.

HIGH VOLTAGE ENGINEERING CORPORATION
BURLINGTON, MASSACHUSETTS, U.S.A.
•
APPLIED RADIATION CORPORATION
•
HIGH VOLTAGE ENGINEERING (EUROPA) N.V.

28 July 1961, Volume 134, Number 3474

SCIENCE

AMERICAN ASSOCIATION
FOR THE
ADVANCEMENT OF SCIENCE

Board of Directors

CHAUNCEY D. LEAKE, *Retiring President, Chairman*
THOMAS PARK, *President*
PAUL M. GROSS, *President Elect*

HARRISON BROWN — DON K. PRICE
HENRY EYRING — ALFRED S. ROMER
H. BENTLEY GLASS — WILLIAM W. RUBEY
MARGARET MEAD — ALAN T. WATERMAN
PAUL A. SCHERER, *Treasurer*
DAEL WOLFLE, *Executive Officer*

Editorial Board

KONRAD B. KRAUSKOPF — H. BURR STEINBACH
EDWIN M. LERNER — WILLIAM L. STRAUS, JR.
PHILIP M. MORSE — EDWARD L. TATUM

Editorial Staff

DAEL WOLFLE, *Publisher* — HANS NUSSBAUM, *Business Manager*

GRAHAM DUSHANE, *Editor*

JOSEPH TURNER, *Associate Editor* — ROBERT V. ORMES, *Managing Editor*

ELLEN E. MURPHY, *Assistant Editor*

NANCY TEIMOURIAN, *Assistant to the Editor*

News: HOWARD MARGOLIS, LILLIAN LEVY, PATRICIA D. PADDOCK

Book Reviews: SARAH S. DEES

Editorial Assistants: NANCY S. HAMILTON, OLIVER W. HEATWOLE, EDGAR C. RICH, JOHN E. RINGLE, BARBARA SUTHERLAND, CONRAD YUNG-KWAI

Staff Assistants: GENEVIEVE M. KIRBY, JEAN P. D. PIEKNIK

Advertising Staff

EARL J. SCHERAGO, *Director*

BERNICE SCHWARTZ, *Production Manager*

Sales: RICHARD L. CHARLES (New York, N.Y., PE 6-1858); C. RICHARD CALLIS (Old Bridge, N.J., CL 4-3680); HERBERT BURKLUND (Chicago, Ill., DE 7-4973); DILLENBECK-GALAVAN (Los Angeles, Calif., DU 5-3991)

SCIENCE, now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at National Publishing Company, Washington, D.C. SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts. Opinions expressed by authors are their own and do not necessarily reflect the opinions of the AAAS or the institutions with which the authors are affiliated. For detailed suggestions on the preparation of manuscripts, see *Science* **125**, 16 (4 Jan. 1957).

Advertising correspondence should be addressed to SCIENCE, Room 1740, 11 West 42 St., New York 36, N.Y.

Change of address notification should be sent to 1515 Massachusetts Ave., NW, Washington 5, D.C., 4 weeks in advance. Furnish an address label from a recent issue. Give both old and new addresses, including zone numbers.

Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢. Single copies, 35¢. Cable address: Advancesci, Washington.

Copyright © 1961 by the American Association for the Advancement of Science.

Arms Control and Self Control

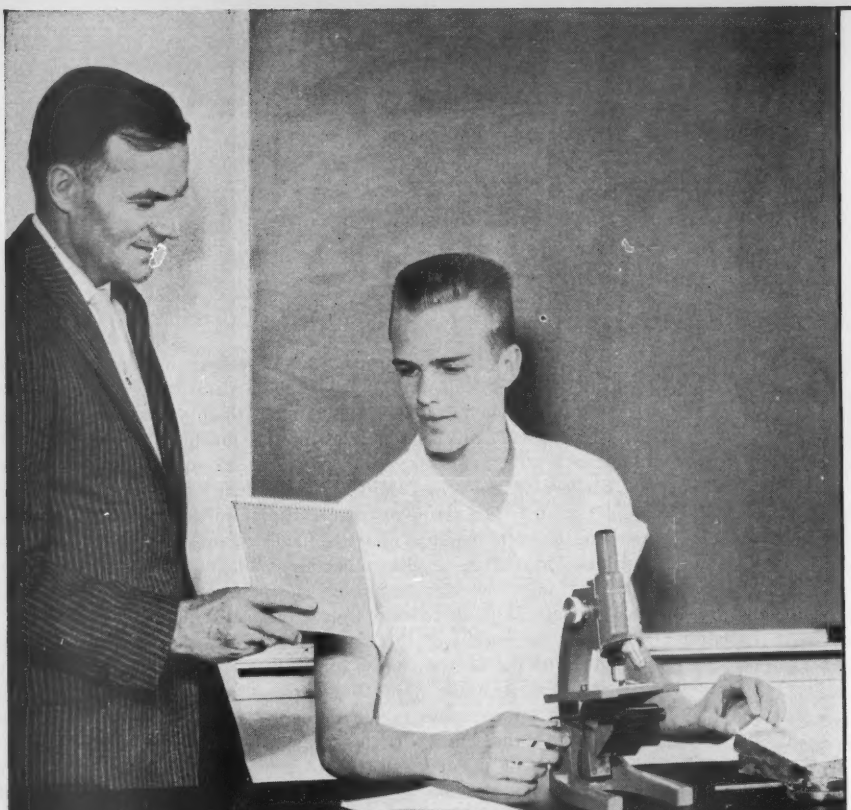
Expectation of gaining a propaganda advantage has led the United States and Great Britain to ask the U.N. General Assembly to review the nuclear test-ban talks, which in almost three years of effort have failed to produce a treaty. The West at this juncture has a good case. Failure to reach agreement does not hinge on some subtle, technical point concerning, say, the conditions under which an on-site inspection may be initiated. The result of such a dispute might be that even if the West were correct, it might find it difficult to make its position understandable. The failure results rather from the not-so-subtle Soviet demand that, in effect, any proposed on-site inspection of a suspected violation must be open to veto by the suspected party.

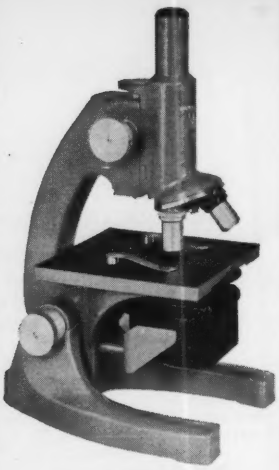
The very blatantness of this demand has been the cause of speculation about why the Soviets choose to proceed in this fashion. One theory has it that the Russians want to provoke us into renewed testing, so that they can test weapons in the atmosphere and still have the blame fall on us. Another theory is that they cannot afford to have inspection teams moving through the Soviet Union, and so are using the talks to reinforce their position in the U.N. concerning the organization of the U.N. directorate. What the Soviets want in the U.N. is a three-man, or "troika," council—East, West, and neutral—with each member possessing veto power. There is probably some truth in both these theories and in a few other theories as well.

Whichever theory is the most true, one thing is clear. The Soviets see more advantage in the treaty for the West than for the East. To the Soviets, the West may be in the position of a gladiator armed with net and trident who wants to negotiate a treaty regulating the use of sword and buckler. The test-ban talks have aroused considerable interest in the United States in the technology and psychology of arms control. If we are determined to see in the present failure some hope for actually instituting somewhere a system of arms control, then the lesson is that in future efforts we must look for agreements in which all parties stand to gain equally, or think they do.

From the viewpoint of effective propaganda, simple as is the West's case, it still does not, it is true, capture the sweep of the Soviet 4-year plan for complete and universal disarmament. To do this, we would have to come up with something like a 4-year plan for the complete and universal abolition of poverty. Yet the West's case ought to convince a few uncommitted persons and nations. There should be enough grim humor in the world to appreciate the virtues of an inspection system which is designed to prevent bootlegging and yet which permits the bootlegger to suspend surveillance whenever it comes time to run the still.

Present efforts to show how the Soviets put up obstacles to disarmament are necessary to prepare public opinion for the possibility of our resuming, in the absence of an inspection system, nuclear weapons testing. But our position in the East-West struggle may also be improved by simply having in our possession a good demonstration of Soviet intransigence. If, in forthcoming discussions, the demonstration proves particularly effective, then the advantage of keeping it untarnished may be one more factor that must be considered in deciding whether to resume testing.—J.T.





BAUSCH & LOMB STANDARD TEACHING MICROSCOPES

Standard size and operation, with optics of laboratory microscope excellence.

BAUSCH & LOMB TRI-SIMPLEX MICROPROJECTOR

Projects mounted specimens or living organisms on screen or tracing pad.

BAUSCH & LOMB BUNSEN SPECTROSCOPE

This basic tool of chemical analysis shows spectra of elements.

Costs are far less when you buy Bausch & Lomb!

You get extra *years* of use out of this all-time best selling school microscope. And your investment is protected for life.

STANDARD TEACHING MICROSCOPES take all the punishment your students can give them—proved by years of maximum use. And now the new exclusive Bausch & Lomb force-proof clutch and lifetime ball-bearing focus make them even more student-proof!

Like all B&L instruments, they're made in America, to the world's highest standards. They're guaranteed for life against defects in workmanship or materials. A nation-wide network of B&L dealers provides you with prompt service.

That's why it costs you far less to buy B&L.

GET YOUR FREE COPY!

of this data brochure covering the world's finest teaching tools for the balanced science program.

BAUSCH & LOMB
SINCE 1853

BAUSCH & LOMB INCORPORATED
77419 Bausch Street, Rochester 2, N. Y.

Please send Brochure D-152, "Recommended Instrumentation for Life Science Teaching."

NAME, TITLE .....

SCHOOL .....

ADDRESS .....

28 July 1961, Volume 134, Number 3474

SCIENCE

CURRENT PROBLEMS IN RESEARCH

Patination of Cultural Flints

Flint artifacts can be dated by cortical changes in mineralogy and texture.

Vernon J. Hurst and A. R. Kelly

Certain flint artifacts have undergone cortical decomposition since they were fashioned several hundred to several thousand years ago and are now invested with a rind or patina. A rough correlation between the thickness of the patina and the age of the artifact has been noted (*1*).

However, many artifacts which are known to be old exhibit little or no cortical change. It is apparent, therefore, that age is not the sole variable on which patination depends. Before patination can be utilized chronometrically the other variables must be determined and their relative effects must be evaluated.

For obsidian, Friedman and Smith (*2*) have shown that only two main variables must be evaluated: composition and mean temperature.

Flint is a more complex material. Its microstructure is more variable and is an important patina-controlling factor. The kind, size, and manner of distribution of impurities profoundly influence flint's susceptibility to attack and the rate of penetration by water and other weathering agents. Even limited study suffices to show that the patination rate may vary more with microstructure and mineralogical impurities than with age. The number of variables is greater for flint than for obsidian, but with careful use of evaluation techniques and a fuller understanding of the processes involved, flint patination can be made to yield useful chronometric data.

Two general types of flint patination can be distinguished. In one type the patina is some shade of brown and is darker than the core. In the other type the patina is a chalky white and is lighter in color than the core. The patina is visible primarily as a color difference in both cases. Before considering in detail the origin of the patina, let us review the properties of flint, such as composition and texture, which are modified during patination and on which the color differences depend.

Composition and Texture of Flint

Flint is composed mainly of small crystallites of silica. The individual crystallites may be so small that their boundaries are invisible even at high magnification, or they may be large enough to be seen by the unaided eye. Their shapes range from needles or fibers to equant (nearly equidimensional) grains. The size and shape of the grains may be regular within a given specimen, or they may vary greatly (Fig. 1). Radiating spherulitic and oölitic textures are common (Fig. 2). Many flints originated as siliceous replacements of fossiliferous carbonate rocks, and outlines of fossils or fossil fragments are commonly preserved (Fig. 3). The mineral impurities in flint include carbonates, iron and manganese oxides, clay minerals, carbonaceous matter, and iron sulfide. The carbonates are typically in the form of rhombs 0.01 to 0.1 millimeter across, distributed unevenly through the flint and often imparting to it a mottling or banding. Less frequently the carbonate is in the form of granular patches or partially replaced fossil fragments. The other mineral impurities are generally distributed unevenly as "dust" or clay-size inclusions which are not individually visible to the eye but which impart a haziness, milkiness, or other color change.

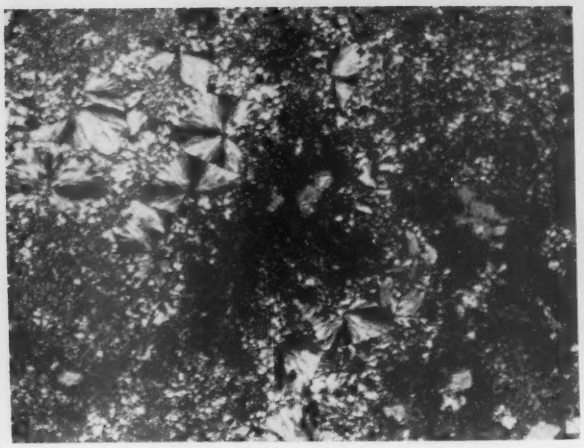
Color of Flint

The color of flint is determined by the grain size, the texture, and the kind and number of impurities.

Grain size and texture largely determine how much of the incident light enters the specimen and passes through and how much is reflected back to the observer by a series of refractions and reflections at grain intersurfaces. The ratio of transmitted light to diffused and reflected light fixes the diaphaneity of the specimen and the *value* of its color (according to the Munsell color system). A flint composed of coarse even-grained quartz, for example, has relatively few refracting and reflecting surfaces, so that most of the incident light enters and passes through (unless it is absorbed by impurities) and the specimen appears colorless-to-light-gray and transparent-to-translucent. A flint composed of fine crystallites, on the other hand, particularly if they vary in size and are irregular in shape, has numerous intersurfaces. Most of the light incident on such a specimen is diffused and reflected out. Consequently the specimen is white and opaque.

The impurities in flint affect the

Dr. Hurst is chairman of the department of geology and Dr. Kelly is professor of anthropology at the University of Georgia, Athens.



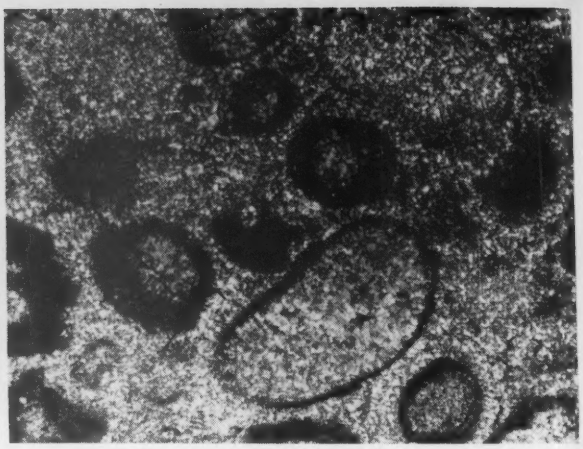


Fig. 1 (left). Photomicrograph of flint, in thin section, showing the variation in grain size and the radiating texture. Fig. 2 (right). Photomicrograph of flint with relic oölitic texture thin section. [Polarized light; about × 73]

color in two ways: (i) by their influence on the ratio of transmitted light to reflected light, and (ii) by their absorption of light. The surfaces between impurities and the enclosing quartz are more effective in refracting and reflecting light than the surfaces between the quartz crystallites themselves. A fractional percentage of impurities may reflect or absorb, or reflect and absorb all the incident light. Whether the flint appears white, gray, black, or some other color depends on how much of the light is reflected and how much is absorbed, and on whether all wavelengths are absorbed equally. Specimens that reflect all the incident light are white. Those that absorb all the light are black. Those that absorb a part of the light are some shade of gray, if all wavelengths are absorbed equally, and are red, brown, or some other color if certain wavelengths are absorbed more than others. The grain size and the texture strongly influence the ratio of reflected light to transmitted light and therefore affect the property of lightness—the *value* of the color. The kinds of impurities determine which wavelengths are absorbed —that is, they determine the *hue* of the color. The amount of the impurity affects the degree of saturation of the color, or its *chroma*, as well as its *value*.

These generalizations are illustrated by Figs. 4, 5, and 6, which are photomicrographs, made with transmitted light, of thin sections of flints. The light gray areas are silica. The moderate gray areas are silica clouded by clay inclusions. The gray rhombic shapes are carbonate minerals. The black areas are opaque impurities in the flint. The proportion of opaque matter is not as great as it appears, inasmuch as the photograph is a projection onto a single plane of all the opaque matter in the body of the section, which is 0.035 millimeter thick. Most of the opaque matter is white—that is, it reflects all visible wavelengths of light. Some of it absorbs all visible wavelengths equally, and is black. Light can penetrate these three flints for only a fraction of a millimeter before a part of it is reflected out and the remainder is absorbed.

The flint shown in Fig. 4 contains abundant white opaque matter which reflects out the incident light before much of it has been absorbed; consequently the flint is light gray. The flint shown in Fig. 6 contains much less opaque matter than that of Fig. 4 and a greater proportion of the opaque matter is black. Incident light penetrates deeper and is largely absorbed; consequently the upper half of this flint is black. A flint with the same

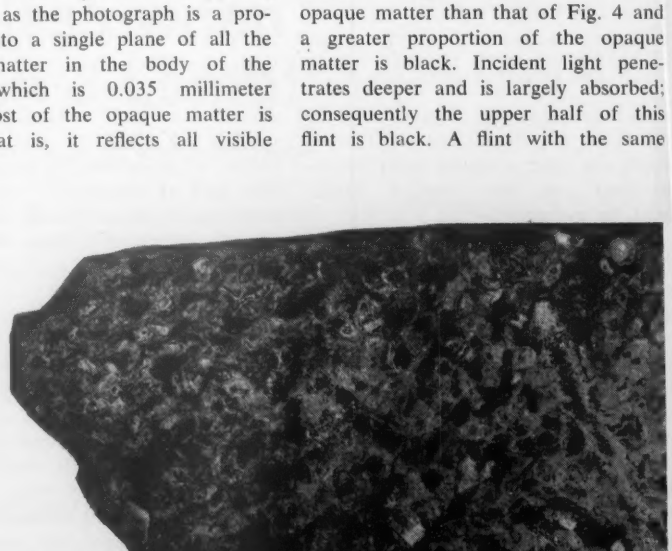


Fig. 3. Photomicrograph of a portion of a brown flint projectile, in thin section. The flint is composed of silicified foraminiferal tests and is colored red brown by unevenly distributed ferruginous matter. Patination processes have modified the exterior distribution of the ferruginous matter, dispersing it more or less evenly and investing the projectile with a continuous smooth rind of hydrous iron oxide. [Transmitted light; about × 9.3]

impurity content but with a finer, uneven texture would be light gray because light would be scattered more at the surface and a greater proportion would be reflected. The opaque-impurity content of the moderately gray flint (Fig. 5) is greater than that of the light gray flint (Fig. 4) and still greater than that of the black flint (upper half of Fig. 6). The thin section represented by Fig. 6 was cut from a black arrowhead mottled with light reddish brown. The black portion (upper half) contains much less opaque matter than the light-colored portion (lower half), but in the lower half the opaque matter is iron-stained and reflects out more light, even while absorbing the shorter wavelengths; hence this portion appears light-colored and reddish brown.

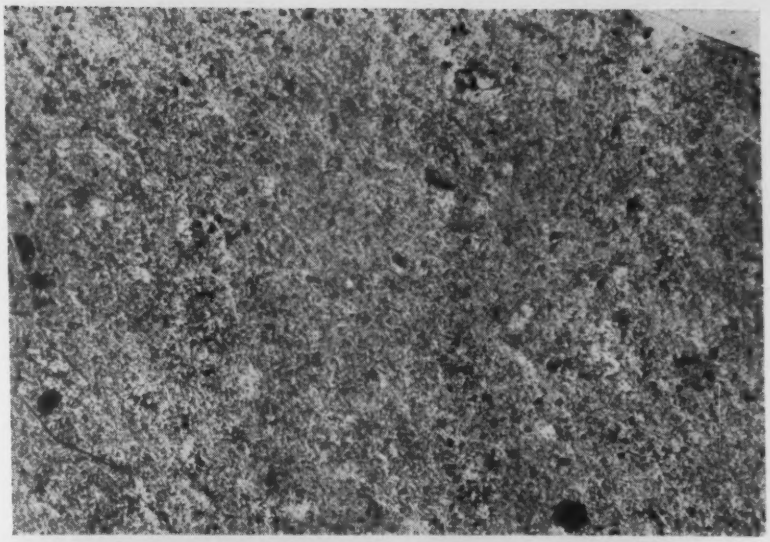
The absorption of light by color centers may be a secondary cause of color in a few flints. The color of most, however, is attributable to the refraction and reflection of light along intergranular surfaces and to the pigmenting effects of a few included impurities.

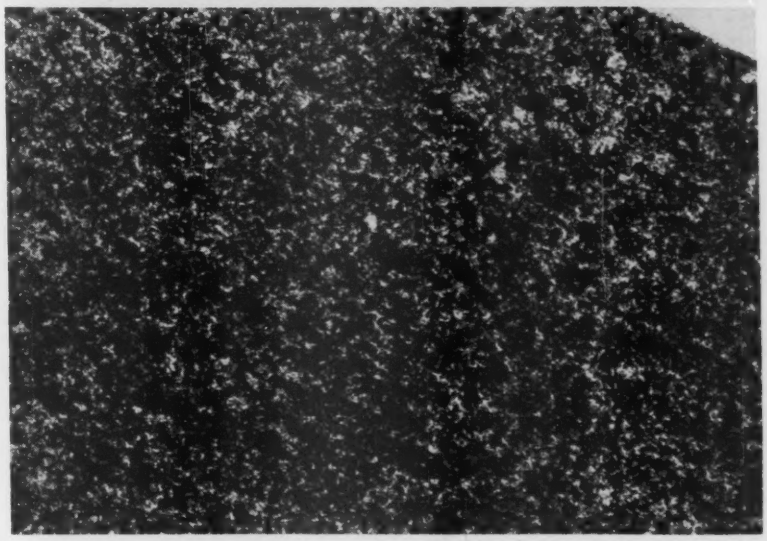
The Patination Process

Obsidian is volcanic glass. Patination in obsidian is essentially a single process, hydration, the rate of which is controlled by the rate of diffusion of water into the glass. For this reason the patination rate is strongly influenced by temperature.

Flint, on the other hand, is mainly silica, which is only slightly susceptible to hydration. Patination in flint proceeds by the interaction of at least three different processes operating, for the most part, on impurities in the flint: (i) oxidation and hydration, (ii) dissolution and leaching, and (iii) chemical and mechanical disaggregation.

Flints which are pure silica, or which contain only chemically stable impurities, cannot patinate, regardless of grain size or texture. To this class belong many of the light gray, trans-





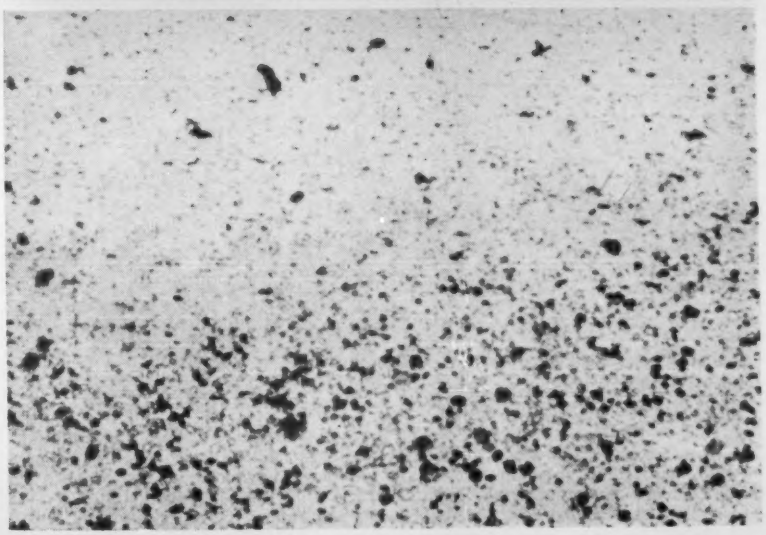


Fig. 4 (top). Photomicrograph of light gray flint, in thin section (transmitted light; × 147). Fig. 5 (middle). Photomicrograph of moderate gray flint, in thin section (transmitted light; × 147). Fig. 6 (bottom). Photomicrograph of black flint (upper half), mottled by pale reddish brown flint (lower half), in thin section (transmitted light; × 175).

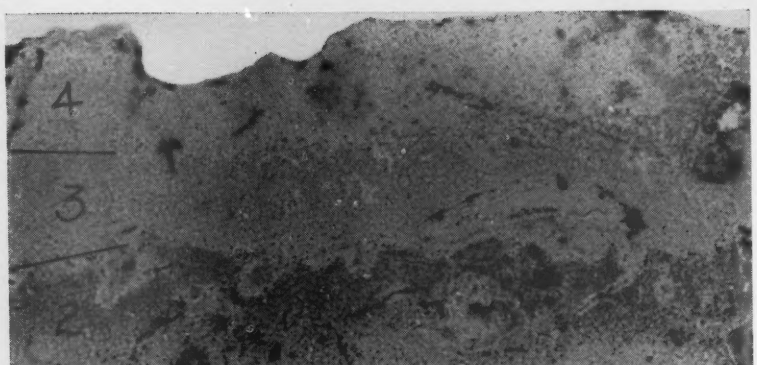


Fig. 7. Photomicrograph of a thin section, showing the characteristic development of the chalky white patina (see text). [Transmitted light; × 96]

lucent flints and the dark flints which owe their color to organic matter.

The flints which contain chemically unstable impurities are all susceptible to patination, but the rate varies greatly, depending on what is the predominant mechanism by which water and other weathering agents penetrate.

For the very fine grained, even-textured flints whose unstable impurities are thinly dispersed, the principal mechanism is diffusion along intergranular boundaries. Flints of this class are most useful for chronometric purposes, because their patination is controlled by only a few variables, foremost of which are (i) mean temperature and (ii) composition, as in the case of obsidian.

Most flints have grains of various sizes, an uneven texture, and inhomogeneously distributed impurities, and their patination is influenced by several factors in addition to temperature and composition. When a new surface is formed on one of these flints, any exposed carbonates begin to slowly dissolve and leach. As they are removed, new surfaces are exposed, the flint becomes more porous, and quartz crystallites are somewhat loosened. Where the weathering agents gain access to inclusions of iron sulfide, the ensuing oxidation and hydration cause local volume changes and create dilute acids which, in turn, attack some of the clays. The iron oxides hydrate and disperse along grain boundaries and in voids. The aggregate effect of the various oxidation, hydration, and dissolution processes is a loosening of quartz crystallites and a greatly increased porosity. This over-all textural change, which greatly increases the reflectivity of the specimen, is seen as a chalky white patina. Where iron oxide or other pigment is dispersed near the surface, the whiteness is correspondingly modified to cream, pink, brown, and so on.

Figure 7 illustrates the characteristic development of a chalky white patina. The core (zone *1*) shows relatively little change. The boundary between zones *1* and *2* is the depth to which patination has progressed. In zone *2* the ferruginous masses have been attacked and partly dispersed. In zone *3* dispersal is pronounced and leaching of ferruginous and calcareous matter is perceptible. In zone *4* leaching is pronounced and the flint is quite porous. The whiteness of the patina is largely due to textural changes and to the increase in reflectivity occasioned by dispersal of the opaque matter, and partly to leaching of carbonates and reddish brown pigment. The formation of the chalky white patina is favored by the high impurity content of clay and carbonate minerals.

Where the water in contact with a ferruginous flint is acidic, a large part of the iron in the patinating layer may be dissolved and leached away from the flint or, instead, may be dispersed along intergranular spaces and only slightly concentrated at the flint's surface. In the first case a chalky white patina develops; in the second case, a brown goethitic rind develops, as shown in Fig. 8. Different sets of local conditions can produce one or the other type of patina from the

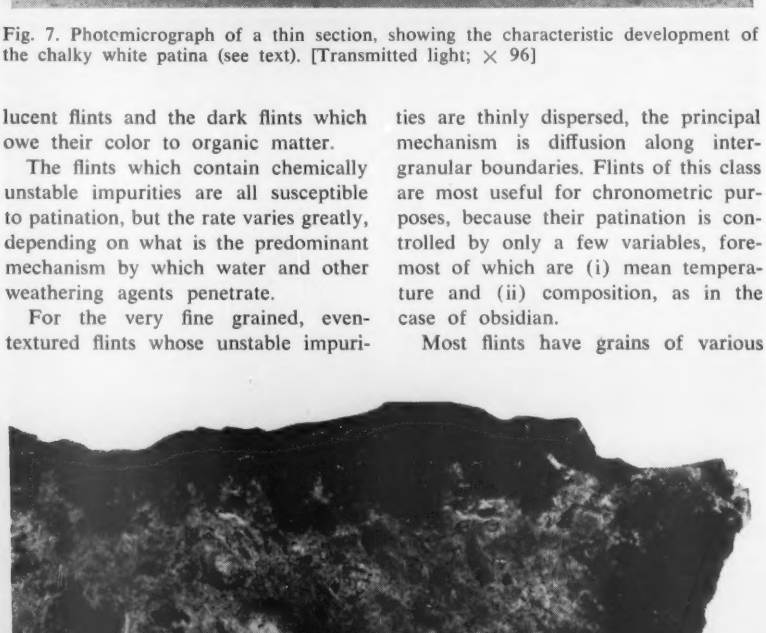


Fig. 8. Photomicrograph of a thin section, showing patina of the brown goethitic type. The patinating processes have caused the ferruginous matter (black areas), which was unevenly distributed originally and is still unevenly distributed in the core, to be dispersed along intergranular spaces in the patinating layer and concentrated on the exterior of the specimen to form a smooth brown goethitic rind. [Transmitted light; × 70]

same kind of flint. Where the flint is exposed to circulating acidic ground water, leaching of iron and development of the chalky patina is favored. Where the moisture involved in patination gains its acidity from chemical reactions within the flint, or where the flint reposes in stagnant phreatic water, the development of the brown goethitic patina is favored.

Texture and microstructure strongly affect patination, as illustrated in the flint shown in Fig. 9. This flint was formed by the silicification of a porous fossiliferous rock. Silica has replaced foraminiferal tests and other fossil fragments in the dark gray areas (Fig. 9, bottom) and has filled voids (the light gray, granular areas). The void-filling silica can be penetrated only through intergranular diffusion, and it contains no visible impurities; consequently it acts as a barrier to patinating agents and cannot, itself, develop a patina. On the right side, the impurity-laden flint in Fig. 9 has patinated normally. At the top, patination has proceeded normally down to the void-filling silica, which has a different texture and has acted as a barrier. The two outer zones of the typical chalky patina—the zone of pronounced leaching (zone *4* in Fig. 7), and the zone of homogenization of impurities (zone *3* in Fig. 7)—continue around the specimen from the right side to the top, as shown by the dashed lines, but the thickness of the next inner zone (zone *2* in Fig. 7) is much reduced. Continued patination of this specimen would thicken the patina on the right side by the inward migration of each zone boundary, but at the top only zone *4* would thicken, at the expense of zones *3* and *2*, without any over-all increase in the thickness of the patina.

Summary

All flints containing unstable impurities are susceptible to patination. The rate of patination varies with many factors: (i) the texture and microstructure of the flint; (ii) its permeability; (iii) the kind, proportion, and distribution of impurities; and (iv) environmental factors, such as temperature and soil chemistry. The thickness of the patina varies also with time.

Two contrasting types of patina can develop: a chalky white patina and a ferruginous brown patina. Both types are observable primarily as a color change, and study of these types is facilitated by a clear understanding of the causes of color in flint.

The color of most flints is the result of repeated refraction and reflection of light at numerous intergranular surfaces, whereby part of the light is internally absorbed and part is reflected back to the observer. The ratio of reflected to absorbed light governs the lightness of the color, or its value. The preferential absorption of certain wavelengths by natural pigments (such as iron oxide and hydrous iron oxide) disseminated through the flint determine the hue of the color.

The color changes produced during patination relate to changes in texture and impurity content occasioned by the attack of weathering agents on impurities in the flint. The creation of voids by the dissolution and leaching of carbonates, the loosening of quartz crystallites, and the dispersal of clays

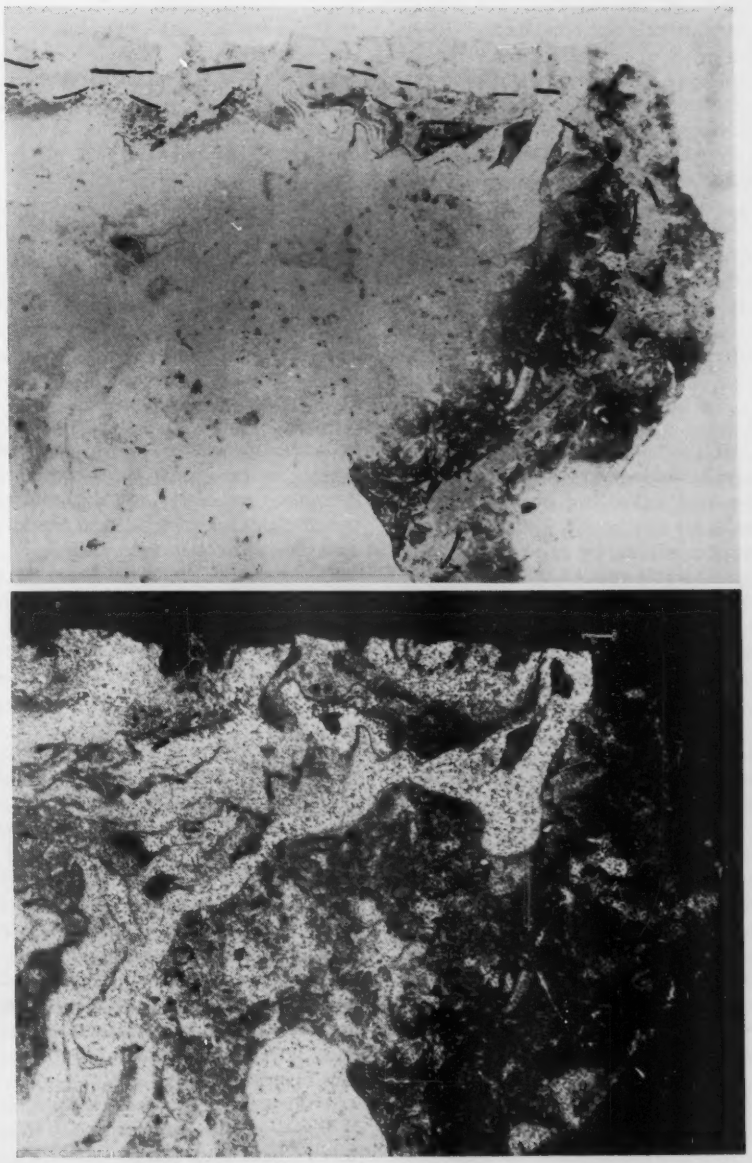


Fig. 9. Photomicrographs of a flint formed by the silicification of a porous fossiliferous rock (see text). [Top, plain light; bottom, polarized light; × 10]

all modify the reflectivity of the flint. Chemical changes involving the pigments, their dispersal along intergranular surfaces, or removal by leaching modify both reflectivity and capacity to preferentially absorb.

Attempts to correlate patina thickness with age, and thus to use flint patinae chronometrically, have proven unsatisfactory because other factors, whose importance in some cases exceeds that of age, have not been taken into account. The texture and microstructure of flint, its permeability, and the kind, proportion, and distribution of impurities can be evaluated by regular petrographic techniques. Environmental factors can be assumed constant for artifacts from the same types of soil in a given climatic region. Only after allowances have been made for these additional variables does the age-dependence of flint patination become clear.

References

1. A. R. Kelly, "Age measurements in decomposed flint," *Georgia Dept. of Mines, Mining and Geol., Geol. Survey Bull. No. 60* (1953), pp. 321–330; —— and V. J. Hurst, *Am. Antiquity* **22**, No. 2 (1956).
2. I. Friedman and R. L. Smith, *Am. Antiquity* **25**, 476 (1960).

Infectious Nucleic Acids, a New Dimension in Virology

Their release from infected tissues and resistance to antibodies may explain some anomalous conditions.

Roger M. Herriott

In the last few years a new dimension in virology was discovered by finding that naked, or free viral nucleic acids are infectious (*1–12*) and that they are not affected by antisera which neutralize whole virus (*3, 5, 8*). Discovered first in plant viruses (*1*), the infective nature of viral nucleic acids was soon afterwards demonstrated for poliomyelitis (*2, 3*), eastern equine and West Nile encephalitis (*2, 4*), Semliki Forest encephalitis (*12*), foot-and-mouth disease (*10*), influenza (*5, 11*), a bacterial virus disease (*7*), and a viral-induced tumor disease (*6*), to mention some representative cases (*31*). Both ribose and deoxyribose-type nucleic acids are among the examples, so there is every reason to believe this is a general phenomenon. Only the efficiency of infection is lower in the nucleic acid preparations than in the case of intact viruses. In all cases the nucleic acid produced the usual disease with the release of whole virus particles.

This capacity of nucleic acid to breach the main defense mechanism of animals led me to several questions and to some speculation which may be worth examining in detail in order to determine the degree to which infective nucleic acids of viruses play an unrecognized role in natural diseases.

The questions which follow serve as the nucleus around which this article is organized.

1) If the viral nucleic acids are released from diseased tissues and if antibodies do not react with nucleic acids, what stops a viral infection?

2) Is the persistence of some infective agents for long periods in the blood of infected subjects—as in serum hepatitis or infectious anemia of horses—due to an infective nucleic acid?

3) Are infectious nucleic acids, either free or in an unreactive envelope, responsible for reports of infectivity in the presence of antibodies?

4) Can the long immunity imparted by infection with certain viral agents be attributed to the maintenance of a low-grade infection, perpetuated by infectious nucleic acid?

5) What will infectious nucleic acids do in an individual vaccinated with a "killed" virus preparation?

6) Since viral nucleic acids can infect hosts not infectible with whole virus, does the search for insect vectors and susceptible hosts which might serve as reservoirs or intermediate hosts need reinvestigation?

7) Do these properties account for the failure to find transmissible agents in human tumors?

While the answers to all or even most of these questions may not lie in the existence of free infectious nucleic acid, the phrasing of the questions deliberately focuses attention on the unusual properties of viral nucleic acids. Questions of a similar nature have been raised briefly by others (*14, 15*).

Viral Nucleic Acid in Infected Cells

Let us first consider the likelihood that free or naked nucleic acid may be present in infected cells and may be liberated to infect surrounding tissues. If there is evidence against such a possibility, it would suggest that the infectious nucleic acids are artificial products of the laboratory and play no part in natural diseases. In two instances in which this point has been examined, free viral nucleic acid has been found or implicated.

Phage-infected *Escherichia coli* have been studied most intensively. In this system, infection is initiated by injection of viral nucleic acid into the host cell (*16*). This is soon followed by synthesis of a "pool" of viral nucleic acid from which progeny virus is formed (*17*). This pool of nucleic acid is maintained essentially constant during intracellular phage formation. At lysis, presumably, the viral nucleic acid from the pool which had not been enclosed in the protein coat is released along with whole virus.

In the case of tissues infected with animal viruses, the evidence is more pertinent to the present discussion. Wecker (*18*) reported that cold phenol, which does not separate viral nucleic

The author is professor of biochemistry in the Johns Hopkins University School of Hygiene and Public Health, Baltimore, Md.

acid from the protein of whole virus, will release infectivity from chick allantoic membranes infected with equine encephalitis virus. No infectivity was released, however, if the infected membranes were first treated with ribonuclease. Since whole virus was not affected by this enzyme, these observations suggest that the infectious nucleic acid is free in the cells and is liberated by cold phenol.

Others (*19*) have found that early treatment of influenza-infected allantoic membranes with ribonuclease reduced the infectivity of the tissue contents; but when the same was found to be true for tissues infected with DNA virus (*20*) as well, it was clear that the action was not necessarily exerted on the viral nucleic acid. This observation is not evidence *against* the presence of free viral nucleic acid in tissues, it merely indicates the difficulty of interpreting complex experiments.

The report of Huppert and Sanders (*9*) is important in the present discussion. These workers reported that they obtained infective ribonuclease-resistant units from tissue infected with encephalomyocarditis virus. These units sedimented much more slowly than whole virus. It will be interesting to know the nature of the material protecting the nucleic acid from the nuclease.

The studies of phage-infected cells and Wecker's report (*18*) are less equivocal than some of the others. They leave little doubt that there is free viral nucleic acid in the particular systems examined.

Infectivity in the Presence of Antibodies

If, as some of the above studies indicate, infective nucleic acid is present in infected cells, then it should sometimes be detectable in extracellular fluids. However, since whole virus may also be present, some means of separating whole virus and viral nucleic acid, or of distinguishing between them, is necessary. The presence of both infectivity and neutralizing antibodies in the same fluid would be highly suggestive, and if the infectivity should then be destroyed by a nuclease, this would be decisive, for no structures other than nucleic acids would react in this way. A search of the literature has turned up a few cases in which the first criterion is satisfied, but no such case has appeared since the infectious nature of viral nucleic acids has been recognized.

Andrewes (*21*) and Todd (*22*) noted many years ago that antivaccinia serum failed to inactivate virus preparations totally, and Smith (*23*) observed that, for a period of several days, rabbits infected with vaccinia had both virus and antibodies in their blood. Berry and Kitchen (*24*) carefully examined a laboratory worker who became accidentally infected with yellow fever virus. They reported that on the fourth and fifth days the blood of this individual contained neutralizing antibodies, as tested in mice, yet showed infectivity for rhesus monkeys. Unfortunately, a close examination of the details surrounding each of these experiments shows that in no instance is the interpretation unequivocal.

Sabin (*25*), however, in a series of papers on the mechanism of immunity to viruses, showed quite clearly that virus preparations mixed with immune serum were noninfectious when inoculated by one route but readily infectious when inoculated by other routes, yet the tissues infected by the several routes were essentially equally susceptible to limiting doses of virus. In rabbits, more than 100 times the concentration of immune serum needed to neutralize 50 to 500 minimal infective doses of B virus inoculated by the intracutaneous route failed to protect against a single minimal infective dose inoculated by the intracerebral route, although the rabbits were found to be equally susceptible by both routes. Similar results were obtained with vaccinia, herpes, or pseudorabies viruses and suggest that this observation is not just an isolated exception. If it is assumed that the viral preparations contained some infectious nucleic acid, then the results become explicable as follows: the immune serum neutralized whole virus and left the infectious nucleic acid, which is destroyed by nucleases before it can infect when inoculated by the cutaneous route but not when inoculated intracerebrally. In this connection it is of interest that the route of inoculation of nucleic acid from foot-and-mouth-disease virus was found to be important (*10*). Inoculation intraperitoneally failed to produce infection, in sharp contrast with the high infectivity of nucleic acid inoculated by the intramuscular pathway. Sabin has suggested (*26*) that his experiments should be repeated in the light of the present hypothesis, and that addition of nucleases to the viral preparations might lead to decisive results.

More recently Dulbecco, *et al.* (*27*) have reported that excess antibody failed to reduce below a minimum the infectivity titer of either western equine encephalomyelitis virus or poliomyelitis virus. Their failure to observe a drop in infectivity with time of incubation suggests that either the serum ribonuclease was ineffective or the viral nucleic acid was protected.

At this point the puzzling character of the disease produced by herpes simplex virus is worthy of discussion. A fraction of the individuals with a history of this disease suffer recurrent episodes which may be initiated by unusual stresses, including fever. In an analysis of this syndrome, Andrewes and Carmichael (*28*) and Brain (*29*) observed that the disease reappeared only in those individuals having neutralizing antibodies. Burnet and Williams (*30*) also studied this problem and confirmed these observations. This conclusion virtually rules out reinfection from an external source and suggests recrudescence. Either the primary infection is kept submerged in the interim and flares up when the control mechanism is altered, or, as in lysogenic bacteria (*31*), an inactive form must be induced or activated. Unless it is assumed that the antibodies cannot reach the reactivated "virus," the latter must be serologically unreactive, a property associated with the free nucleic acids. If the hypothesis thus far is correct, then responsibility for submergence of activity between episodes could be attributed to the humoral nucleases. Under stresses such as fever, which precede recurrence of the disease, the nucleases may become inhibited and may thereby permit the infectious nucleic acid from the low-level infection to enlarge the area of infection and produce symptoms —all this in the presence of antibodies. White blood cells, which release a deoxyribonuclease inhibitor in vitro (*32*), accumulate in the blood during fever, so that if the nucleic acid of herpes is of the deoxyribonucleic acid type, as appears plausible (*33*), the model is complete.

Nonantigenic Viral Agents

At this point I shall consider a few specific diseases, each of which has an anomalous facet suggesting either that the infective agent is nonantigenic or that at some stage it is nonantigenic.

The anomalies range from "carrier" states where no antibody is demonstrable to recrudescence in the presence of antibodies, as in the already discussed example of herpes simplex.

The viral agent that causes serum hepatitis is not known to infect animals other than man, a fact which seriously limits our ability to obtain reliable information about its properties. The disease is distinguished by a long period (up to 50 days) of viremia preceding the onset of symptoms, which in some instances may not develop for three to four months after exposure (*34*). If there were a protein component of this agent, antibody would be expected to form and neutralize the agent in this time interval. There are also reports of repeated attacks of the disease (*34*). These reports, supported by one that gamma globulin from convalescent patients has failed to prevent infection with known infective material (*24*, *35*), are evidence for an immunologically unreactive agent. However, the stability of the agent for long periods in serum requires that the viral nucleic acid must be protected from the nucleases by a membrane of nonantigenic material, perhaps lipid. The report by Huppert and Saunders (*9*) of finding a ribonuclease-resistant infective encephalomyocarditis particle that sediments more slowly than the usual virus particles may be pertinent.

Other diseases in which the viral agent persists for very long periods in the blood without antibody formation include infectious hepatitis of mice (*36*), infectious anemia of horses (*37*), and lymphocytic choriomeningitis in mice (*38*), although in the last instance other explanations have been offered (*39*).

To imply that all nonantigenic disease agents are free nucleic acids is not my intent, and to draw such a conclusion would be to disregard the fact that free nucleic acids are extremely vulnerable to nucleases of blood (*32*). Since the infectious agents persist for long periods in the blood, it is necessary to suppose that either (i) the infective nucleic acid is released by the tissues more rapidly than it is being removed or digested, or (ii) the nucleases are suppressed in these cases by inhibitors (*32*), or (iii) the nucleic acid is surrounded by a nonantigenic membrane which protects it from nucleases (*9*). At the present time there are too few data for us to decide among these possibilities, although decisive experiments are feasible.

Increased Host Range of Nucleic Acid

A certain property of viral nucleic acid which was discovered independently in three different laboratories (*40*, *41*) will have particular importance if subsequent work shows it to be a general property of viral nucleic acids. It was found that the range of cell hosts for viral nucleic acids is greater than for the whole virus. Thus, Syverton's group (*40*) showed that rabbits, hamsters, and guinea pigs, as well as certain of their tissues, were infectable by a variety of enteric virus nucleic acids, including poliomyelitis, but not by whole viruses. A somewhat similar case has recently been found for a bacterial virus (*7*). In the light of this remarkable discovery, tests for susceptible tissues or hosts, which in the past were made with whole virus, will in many instances need re-examination with viral nucleic acids.

Tumor Agents

Despite an ever-increasing list of viral agents shown to initiate tumor formation in animals, some of which become malignant (see *42* for a more complete discussion), few such agents, if any, have been found associated with malignant growth in man. Questions naturally arise concerning the reason for this difference. If human tumors are caused by viral agents, are these agents in a masked form, like the papilloma virus in the domestic rabbit (*43*), or is the tumor agent a viral nucleic acid which functions *in situ* but, when transferred to another host, is so slow in infecting other cells that it is destroyed by the nucleases? The failure to find viral antigen in the basal germinal layer of the rabbit papilloma where neoplasia is occurring, in contrast to the easily observable quantities of antigen higher in the wart, led Noyes and Mellors (*44*) to suggest that it is the nucleic acid that is infectious, and led Shope (*15*) to wonder if the more labile viral nucleic acid is responsible for the neoplasia.

In recent years the production of myxomatosis in rabbits through the combined action of avirulent Shope fibroma virus and heat-killed myxoma virus [the Berry-Dedrick phenomenon (*45*)] has been clarified somewhat. Shack and Kilham (*46*) have shown that the nuclease-sensitive nucleic acid and a small quantity of protein from the myxoma virus must be included with the fibroma virus. The nucleic acid is not infectious alone, but requires the supporting action of the fibroma virus, either to change the permeability of the host cell to nucleic acid or because the nucleic acid is incomplete as prepared and must acquire some missing part from the related strain before it can infect. Similar "transformations" have been reported for other pox viruses (*47*).

In the case of the polyoma virus, a nuclease-sensitive infective nucleic acid has been reported (*6*) which produces typical tumors, so it is not unreasonable to look for such an agent in those instances where the classical type of search for whole virus has failed, but where success in looking for an infectious nucleic acid may depend on the suppression of the naturally occurring nucleases.

Nucleases as a Defense Mechanism

In general, the initiation of an infection depends on whether at least one viral particle can penetrate a susceptible cell where it is safe from the usual host defense mechanisms. Once a cell is infected, the spread of the infection in the tissues is determined by the same forces plus the added, but little understood, feature of cell-to-cell transmission of the infective agent, possibly without its exposure to extracellular insults. The concentration (titer) of virus, number of susceptible cells, and time of penetration are on the side of infection and against the forces tending to inhibit the process. In general, this inhibition of infection by whole virus is due to antibodies, although there may be other deterrents, such as interferon (*48*). Since nucleic acids are not influenced by antibodies to whole virus (*3*, *5*, *8*), the possibility that nucleases which are known to be highly destructive of nucleic acids (*49*) might serve as an additional defense mechanism deserves consideration.

My colleagues and I have determined blood levels in human beings of both deoxyribonuclease and ribonuclease (*32*). We found that the active nuclease in the blood of the average adult reduced the infectivity of a deoxyribonucleic acid agent to 10 percent (a 1-log drop) in 12 minutes at 37°C, whereas a ribonucleic acid agent was reduced to the same level in 2 to 3 seconds. This information shows that, other things being equal, an infective deoxyribonucleic acid would have 100 times as great a chance of initiating an infection as would ribonucleic acid of

viral origin. Virologists working with tissue cultures have recognized that the nucleases of serum (*2, 3, 11*) rapidly destroy viral nucleic acid infectivity. On the other side, nucleic acids are taken up by susceptible, or "competent," cells in less than a minute or two (*3, 50*), and there are, of course, many instances (noted earlier) of infections produced in animals by inoculating only the viral nucleic acid. It may be considered as established, therefore, that for nonimmune animals the normal nuclease levels are not high enough to prevent infection, although there is one report (*10*) that the route of inoculation of viral nucleic acid was critical. It is possible, however, that in these instances of infection the concentrations of nucleic acid inoculated were inordinately high relative to those that might develop in infected tissues.

Considerable variation in the blood nuclease levels of individuals, due, perhaps, to a release in vivo of either enzymes or their inhibitors from the cellular elements of blood (*32*), has been observed. Such variations, enhanced perhaps by the effects of a specific disease or physiological condition, might well produce wide differences in the response of individuals to infectious nucleic acids.

The balance between nuclease destruction and infectivity may be so fine in some instances that failure to find infective agents when their existence had been suspected—as in cancer research—might be due to an increase in nuclease concentration. This increase need not be excessive by ordinary standards. In looking for infectious nucleic acids, utilization of the nuclease inhibitors found in certain cells of blood (*32*) should prove of value.

Permanent Immunity

It is generally agreed (*51*) that after recovery from certain viral diseases such as poliomyelitis or yellow fever, individuals are permanently immune to the agent. To account for this it has sometimes been thought that perhaps in these cases there is a very low level infection maintaining a stimulus for antibody formation, but no very appropriate model for maintaining an infection in the presence of antibodies has been suggested. The infectious nucleic acid provides just such a model. The whole virus, released by tissues, would be rapidly neutralized by humoral antibodies and would provide an anamnestic stimulus, while released nucleic acid would infect a few susceptible cells and maintain the infection. The larger range of cell hosts for the nucleic acid (*40, 41*) may be particularly important in this connection.

Does a "Killed" Vaccine Protect against Infective Nucleic Acid?

Perhaps many of the questions raised in the earlier sections of this article can be tested by challenging, with viral nucleic acid, animals vaccinated with a "killed" whole virus preparation. Since the vaccinated animal presumably has no tissue or local immunity and possesses only antibodies which do not inhibit the free nucleic acid, there is every reason to expect some cells to become infected. Then, depending on whether infectious nucleic acid is thereafter released by infected cells and on how cell-to-cell infection takes place, any of several possible results may be anticipated.

If only whole virus is released, the antibodies induced by the vaccine should stop the infection promptly, and the animal should show little or no effect. If the tissues release infectious nucleic acid which spreads the infection to other cells and tissues, then symptoms may be observed.

It would be important in any event to examine these animals for a viremia by making undelayed inoculation of blood samples into unvaccinated susceptible animals by the route most sensitive to low levels of viral nucleic acid. A delay in transfer might permit nucleases of the blood to destroy any nucleic acid. There is considerable individual (*32, 52*) and species (*52*) variation in nuclease levels, so that extrapolations are at best only suggestive. The success of such an experiment might also depend on the particular disease agent.

It may be argued that observations from a vast number of neutralization studies of viremic agents virtually eliminate the possibility that an infective nucleic acid phase is present in blood or comparable fluids. This objection would be difficult to answer were it not customary for virologists to use serum samples in their tests; the time consumed in preparing the sample might well be sufficient for nuclease destruction of the infectivity, especially since deoxyribonuclease levels in serum are ten times higher than in blood, because of the release of this enzyme from platelets during clotting (*32*).

It is clear from the protection afforded by passive immunization and the correlation between rise in the level of antibodies and reduction in the intensity of symptoms that the whole virus plays the major role in most diseases. There are, however, exceptions, or features which do not fit such a simple picture, and it is these that are being viewed in the light of the recently discovered properties of viral nucleic acids. The true significance of infectious nucleic acids in natural infections will not be known until many carefully planned experiments have been performed which take into consideration some of the properties which have been described.

The control of viral infections by nonspecific mechanisms such as inflammatory reactions and interferon formation (*48*) has recently been emphasized (*53*). Nuclease action may be included among the nonspecific mechanisms. One or more of these mechanisms could interfere with the disease produced by a viral nucleic acid and explain the observed recovery, but it is not now known which mechanism is responsible for this action.

Summary

Viral nucleic acids have been found to be infectious for tissues and animals, yet are nonantigenic and resistant to antibodies against whole virus. Other unique properties, such as their host range and their susceptibility to nuclease action, render them a wholly new dimension to be reckoned with in virology.

These properties may explain a number of conditions which at present are considered anomalous. The release from infected tissues of even a small proportion of total virus as free nucleic acid could, in an otherwise immune individual, lead to a low level of infection which would, perhaps, explain permanent immunity. If the proportion of nucleic acid is higher, or if the nucleic acid is resistant to nucleases because of an inert envelope, such conditions as "carrier" states—that is, viremias with or without antibodies—are possible.

Note added in proof: The recent article by J. D. Ebert and F. H. Wilt (*54*) came to my attention after the present article was written. Ebert and Wilt's excellent article indicates the impact of the newer knowledge of viral nucleic acids on the ideas developing in the field of embryology.

References and Notes

1. H. Fraenkel-Conrat, *J. Am. Chem. Soc.* **78**, 802 (1956); A. Gierer and G. Schramm, *Nature* **177**, 702 (1956); ———, *Z. Naturforsch.* **11b**, 138 (1956).
2. J. S. Coulter, H. M. Bird, R. A. Brown, *Nature* **179**, 859 (1957).
3. H. E. Alexander, G. Koch, I. M. Mountain, O. Van Damme, *J. Exptl. Med.* **108**, 493 (1958).
4. E. Wecker and W. Schafer, *Z. Naturforsch.* **12b**, 415 (1957).
5. H. F. Maassab, *Proc. Natl. Acad. Sci. U.S.* **45**, 877 (1959).
6. G. A. DiMayorca, B. E. Eddy, S. E. Stewart, W. S. Hunter, C. Friend, A. Bendich, *ibid.* **45**, 1805 (1959).
7. G. D. Guthrie and R. Sinsheimer, *J. Mol. Biol.* **2**, 297 (1960).
8. F. Sokol, H. Libikova, J. Zemla, *Nature* **184**, 1581 (1959).
9. J. Huppert and F. K. Sanders, *ibid.* **182**, 515 (1958).
10. F. Brown, R. F. Sellers, D. L. Stewart, *ibid.* **182**, 535 (1958).
11. G. L. Ada and S. G. Anderson, *ibid.* **183**, 799 (1959).
12. P. Y. Cheng, *ibid.* **181**, 1800 (1958).
13. For a more complete listing, see L. M. Kozloff, *Ann. Rev. Biochem.* **29**, 475 (1960).
14. A. B. Sabin, in *Rept. Proc. Intern. Congr. Microbiol. 7th Congr. Stockholm* (1958), p. 253.
15. R. E. Shope, personal communication.
16. A. D. Hershey and M. Chase, *J. Gen. Physiol.* **36**, 39 (1952).
17. A. D. Hershey, J. Dixon, M. Chase, *ibid.* **36**, 777 (1953); A. D. Hershey, *ibid.* **37**, 1 (1953).
18. E. Wecker, *Virology* **7**, 241 (1959).
19. J. LeClerc, *Nature* **177**, 578 (1956); F. M. Burnet, P. Lind, B. Perry, *Australian J. Exptl. Biol. Med. Sci.* **35**, 517 (1957).
20. I. Tamm and R. Bablanian, *J. Exptl. Med.* **111**, 351 (1960).
21. C. H. Andrewes, *J. Pathol. Bacteriol.* **31**, 671 (1928).
22. C. Todd, *Brit. J. Exptl. Pathol.* **9**, 247 (1928).
23. W. Smith, *ibid.* **10**, 93 (1929).
24. G. P. Berry and S. Kitchen, *Am. J. Trop. Med.* **11**, 365 (1931).
25. A. B. Sabin, *Brit. J. Exptl. Pathol.* **16**, 169 (1935); I am grateful to Dr. Sabin for calling my attention to this article.
26. ———, personal communication.
27. R. Dulbecco, M. Vogt, A. G. R. Strickland, *Virology* **2**, 162 (1956).
28. C. H. Andrewes and E. A. Carmichael, *Lancet* **1**, 857 (1930).
29. R. B. Brain, *Brit. J. Exptl. Pathol.* **13**, 166 (1932).
30. M. F. Burnet and S. W. Williams, *Australian J. Med.* **1**, 637 (1939).
31. A. Lwoff, *Bacteriol. Revs.* **17**, 270 (1953).
32. R. M. Herriott, J. H. Connolly, S. Gupta, *Nature* **189**, 817 (1961).
33. A. Newton and M. G. P. Stoker, *Virology* **5**, 549 (1948); S. Osterhout and I. Tamm, *Federation Proc.* **18**, 590 (1959).
34. W. P. Havens and J. R. Paul, in *Viral and Rickettsial Infections of Man*, T. M. Rivers and F. L. Horsfall, Jr., Eds. (Lippincott, Philadelphia, ed. 3, 1959), chap. 27, p. 570.
35. M. E. Drake, J. A. Barondess, W. J. Bashe, Jr., G. Henle, W. Henle, J. Stokes, Jr., R. B. Pennell, *J. Am. Med. Assoc.* **152**, 690 (1953); G. S. Mirick has obtained some evidence which suggests that gamma globulin may be protective (personal communication).
36. A. W. Gledhill and C. H. Andrewes, *Brit. J. Exptl. Pathol.* **32**, 554 (1951); A. W. Gledhill, G. W. A. Dick, C. H. Andrewes, *Lancet* **2**, 509 (1952); J. S. F. Niven, A. W. Gledhill, G. W. A. Dick, C. H. Andrewes, *ibid.* **2**, 1061 (1952).
37. M. N. Dreguss and L. S. Lombard, *Experimental Studies in Equine Infectious Anemia* (Univ. of Pennsylvania Press, Philadelphia, 1954).
38. E. Traub, *J. Exptl. Med.* **63**, 847 (1936); **68**, 229 (1938).
39. F. M. Burnet *Principles of Animal Virology* (Academic Press, New York, 1955), p. 244.
40. J. J. Holland, L. C. McLaren, J. T. Syverton, *Proc. Soc. Exptl. Biol. Med.* **100**, 843 (1959); *J. Exptl. Med.* **110**, 65 (1959).
41. I. M. Mountain and H. E. Alexander, *Proc. Soc. Exptl. Biol. Med.* **101**, 527 (1959); P. De Somer, A. Prinzie, E. Schonne, *Nature* **184**, 652 (1959).
42. *Cancer Research* **20**, 669 (1960).
43. R. E. Shope, *Proc. Soc. Exptl. Biol. Med.* **32**, 830 (1935).
44. W. F. Noyes and R. C. Mellors, *J. Exptl. Med.* **106**, 555 (1957).
45. G. P. Berry and H. M. Dedrick, *J. Bacteriol.* **32**, 356 (1936).
46. J. Shack and L. Kilham, *Proc. Soc. Exptl. Biol. Med.* **100**, 726 (1959).
47. F. Fenner, I. H. Holmes, W. K. Joklik, G. M. Woodroofe, *Nature* **183**, 1340 (1959); T. Hanafusa, H. Hanafusa, J. Kamahora, *Virology* **8**, 525 (1959).
48. A. Isaacs, *Symposium Soc. Gen. Microbiol. 9th* (1959), p. 102; R. R. Wagner, *Bacteriol. Revs.* **24**, 151 (1960).
49. M. McCarty and O. T. Avery, *J. Exptl. Med.* **83**, 89 (1946); G. Schramm and A. Gierer in *Cellular Biology, Nucleic Acids and Viruses* (New York Academy of Sciences, New York, 1957), vol. 5, p. 299; K. Sprunt, S. Koenig, H. E. Alexander, *Virology* **13**, 135 (1961); J. Polatnick and H. L. Bachrach, *Proc. Soc. Exptl. Biol. Med.* **105**, 486 (1960).
50. H. H. Henstell, R. L. Freedman, B. Ginsburg, *Cancer Research* **12**, 346 (1952); S. H. Goodgal and R. M. Herriott, *Federation Proc.* **15**, 1923 (1956); L. Lerman and L. Tolmach, *Biochim. et Biophys. Acta* **26**, 68 (1957); M. Fox and R. D. Hotchkiss, *Nature* **187**, 1002 (1960); S. H. Goodgal and R. M. Herriott, *J. Gen. Physiol.*, in press; F. M. Sirotnak and D. J. Hutchinson, *Biochim. et Biophys. Acta* **36**, 246 (1959); S. M. Gantler, *Nature* **184**, 1505 (1959); E. Borenfreund and A. Bendich, *J. Biophys. Biochem. Cytol.* **9**, 81 (1961).
51. J. E. Smadel, in *Viral and Rickettsial Infections of Man*, T. M. Rivers and F. L. Horsfall, Jr., Eds. (Lippincott, Philadelphia, ed. 3, 1959), chap. 1.
52. N. B. Kurnick, *Arch. Biochem. Biophys.* **43**, 97 (1953).
53. A. Lwoff, *Bacteriol. Revs.* **23**, 109 (1959).
54. J. D. Ebert and F. H. Wilt, *Quart. Rev. Biol.* **35**, 261 (1960).

Financing Scientific Research in Australia

Federal funds and research agencies play a dominant role in the national research effort.

S. Encel

The character of scientific research in Australia must be understood in relation to a continent presenting enormous natural difficulties for European settlement. It is far from Europe and North America (Sydney, the largest city, is 12,000 miles from London). Two-thirds of its area of nearly 3 million square miles is virtually uninhabitable. In 1939 the population was close to 7 million; in 1959, after a decade of the most rapid growth in its history, the figure reached 10 million—less than that of Greater New York. The combination of geographical remoteness, difficult terrain, limited rainfall, limited natural resources, and sparse population has meant a slow rate of growth. In particular, it meant a slow rate of industrialization up to 1939, with primary production (of minerals and of pastoral and farm products) greater than the total output of secondary industry. Since World War II, secondary industry has come to account for a higher proportion of gross national product than primary industry, but Australia's prosperity still depends heavily on exports of wool and farm products, which provide 75 to 80 percent of export income. This income has generally been sufficient to support a high standard of living, especially since it has occurred in conjunction with a pattern of governmental economic intervention sometimes described as "state socialism" (*1*), whose effect has been to maintain a high level of wages (surpassed only in North America).

Industrial growth, hampered by the small internal market, by limitations in raw materials, and by remoteness from possible export markets, has been particularly dependent on high tariffs and on the large-scale investment of

The author is a senior lecturer in political science and public administration at the Australian National University, Canberra City, in the School of General Studies.

capital from overseas, mainly from Britain. Investment funds for public utilities such as railways, electricity, urban transport and water supply have been raised very largely through government action. As noted in W. W. Rostow's *Stages of Economic Growth*, mass consumption was reached before industrial maturity.

According to the official "White Paper on National Income and Expenditures," the gross national product for 1958–59 amounted to £A6250 million ($14,000 million), and national income, to £A5069 million ($11,400 million). Farm income for that year was £A458 million ($1030 million), representing 8 percent of total disposable income. According to the latest census, 13.4 percent of the work force was in agriculture, forestry, and fishing, compared with 12.5 percent in the United States and 19.3 percent in Canada, and 30 percent was in manufacturing and in power and water supply. These figures underline the importance of farm production in providing the export income which is needed for economic growth, as compared with its share in national income. Wool, moreover, normally accounts for between 40 and 50 percent of export income.

Political Background

Familiarity with the economic factors just sketched is indispensable to an understanding of the way in which scientific research in Australia has developed, largely under the auspices of the federal government (normally referred to in Australia as the Commonwealth government). An understanding of the political and constitutional framework is, however, equally important.

The federal constitution, which came into force in 1901, was framed by colonial politicians who were anxious to give away as little power as possible to a federal body whose establishment they could block no longer. They thought the American pattern the most suitable for their purpose, but to give even greater safety to the states (which the six colonies then became), the new Commonwealth government was given only certain enumerated powers, without even the general power to make laws for the peace and good government of Australia. All other "residual" powers remained with the states.

The actual development of Australian politics has largely made nonsense of this constitutional division of functions. The principal reason for this is that the financial predominance of the Commonwealth government—a predominance which has become steadily greater since federation—has given it the real power within the federal structure.

Until 1939, however, successive federal governments had done comparatively little to extend the functions of the Commonwealth into fields which the states neglected because of lack of funds, and state premiers were quick to oppose proposed extensions of Commonwealth functions on the grounds that these would involve "overlapping" or "duplication" of state activities. When the Commonwealth finally did enter the field of research, great care was taken to provide for consultation with state bodies to prevent duplication of effort. In education, now the greatest single area of state expenditure, resistance to "intrusion" of the Commonwealth government has been long drawn out.

The central role of governmental intervention in economic and social affairs has been taken for granted in Australian politics for more than two generations. In the name of the principle of "national development," even conservative groups have not only acquiesced in but have actively fostered government action in fields where, in the United States at least, such action is still considered "socialistic" (*2*). Policies of "development" may require the government not only to provide the conditions under which private enterprise can operate effectively but also to go into business on its own account. In the process, traditional distinctions between the proper spheres of public and private effort tend to vanish. Research, which may be viewed as an aspect of "developmental" policy, is a case in point. The institutions established by the Commonwealth government since 1916 have been devoted to "scientific and industrial" research, or, to use more up-to-date jargon, "pure and applied" research. In part, this represents a pragmatic recognition of the fact that Australian industry was not likely to undertake any significant amount of research on its own account, but it also involves the principle that governments have a positive role to play in the economic life of a modern community (*3*).

Public Institutions of Research

In brief, the constitutional and administrative status of the various public bodies carrying out research is as follows.

Agriculture. Each of the six states possesses a department of agriculture, whose functions include regulation, extension services, testing and inspection, agricultural education, and research. These bodies are all within the normal departmental framework—that is, they are staffed by permanent civil servants, a minister is politically responsible for their activities, and they are financed through annual budgetary appropriations. Their research activities, carried out mostly on experimental farms, account for about 15 percent of their total expenditure, which was £A10.5 million in 1958–59. In 1934 the Commonwealth government was instrumental in setting up a federal-state consultative body, the Australian Agricultural Council, which comprises all the state ministers of agriculture under the chairmanship of the federal Minister for Primary Industry. The council is served by a standing committee comprising the permanent heads of the state agriculture departments and officials representing interested Commonwealth agencies. Between them, the two bodies exercise considerable influence on research policy in agriculture.

Universities. Until 1946, all universities, with one unimportant exception, were state foundations. The federal constitution does not give the Commonwealth government any powers in regard to education except in the federal territories, which include the Australian Capital Territory, the site of Canberra. All state universities are set up under acts of parliament which are designed to give them the maximum degree of autonomy. Each university is administered by a council (in some cases called senate) whose composition is prescribed by the statute. These governing bodies are given corporate status, with perpetual succession, a common seal, the right to own and administer property, and the power of making regulations and rules on all matters pertaining to the functions of the university. None of these powers is subject to approval by the government, which has no statutory power to direct the university council in any way. On the other hand, as the bulk of university support comes from annual

appropriations in the state budget, the government's influence over general policy can be considerable. In addition, a number of members of the university council are chosen by the government, and in some cases this can lead to a degree of influence which does not meet with the approval of the academic staff.

Before World War II, university research funds and facilities were small. Universities were regarded primarily as schools for training professionals required by the community—doctors, engineers, lawyers, teachers, chemists. As a result, a significant number of the most talented graduates have always been attracted abroad, mostly to Britain, and their research work has been done overseas. The names of Florey, Oliphant, Massey, Lawrence Bragg, Raymond Dart, and Samuel Alexander are among the best known (*4*). World War II brought a sharp awareness of this problem, and in 1946 the Commonwealth government established the Australian National University in the Australian Capital Territory. This institution was originally conceived as being devoted entirely to research and postgraduate study, somewhat on the lines of Johns Hopkins (*5*). Research in the natural sciences is concentrated in three sections of the university—the Research School of Physical Sciences, directed by Sir Marcus Oliphant, with emphasis on the study of high-energy particles; the John Curtin School of Medical Research, with emphasis on research in biochemistry and medical chemistry; and the Commonwealth Observatory on Mount Stromlo, now directed by Bart J. Bok, formerly of Harvard. In 1958–59, the Australian National University spent about £A1 million ($2.25 million) on scientific research, including capital expenditure. In addition, astronomical observation is carried out by foreign universities at the observatory; typical of such programs is a joint Yale-Columbia project.

In addition to establishing the National University, the Commonwealth government has entered the field of university finance on a large scale. Until 1936, the Commonwealth had made small *ad hoc* research grants to the universities. In 1936 a 5-year program was inaugurated by which £A30,000 ($100,000 at the then current rate) was to be spent annually for grants to support research in the physical and biological sciences. By 1950 the amount had reached £A100,000 ($225,000) annually, but such grants have since been absorbed in much larger general grants. In 1950 a new era in university finance opened with the passage of a federal act of parliament authorizing the Commonwealth to make grants to the states for payment to the universities. (Under section 96 of the federal constitution, the Commonwealth is empowered to make grants to the states on such terms and conditions as it thinks fit.) Until 1958 these grants were made on the basis of a formula which provided for both an outright grant and a "second level" grant, depending on the amount of state expenditure up to a certain maximum. In 1957–58, the total Commonwealth grant under this formula was £A3 million ($6.75 million), representing less than one-fifth of total university expenditure. In 1957 the federal government appointed a committee of inquiry into university education (itself a step which would have been almost unthinkable 10 years earlier), headed by Sir Keith Murray, chairman of the University Grants Committee of Great Britain. The committee recommended a large increase in Commonwealth financial assistance and the setting up of a permanent committee on the British pattern to advise the federal government on future grants. This body, the Australian Universities Commission, was established in 1959. In 1958–59, Commonwealth expenditure on universities rose to nearly £A7 million ($15.5 million), a figure which represented 35 percent of the universities' total income of £A20 million. Of the remainder, 45 percent came from the states, 15 percent from fees, and 5 percent from other sources, including private benefactions (*6*).

This revolution in university finance is the result of a remarkable expansion of university education. In 1939 there were approximately 12,000 students enrolled at Australia's six universities and two university colleges (institutions of university status but without degree-granting powers). In 1959 there were ten universities and two university colleges, with a total enrollment of almost 50,000. This rapid growth is still, however, not accompanied by a parallel growth in university research. The Murray report drew attention to the relatively small numbers of postgraduate students and pointed out that Australian universities produced, in proportion to the population, only one-quarter as many Ph.D.'s as the United Kingdom and only one-fifth as many as the United States (*7*).

University research is financed partly from the general budget, partly from private benefaction, and partly from grants which come principally from the federal government. In 1958–59, the universities spent approximately £A1 million for "research and other special purposes." In Britain and the United States it is customarily assumed that half the sum expended on salaries is actually research expenditure. The proportion is certainly lower in Australia and may be tentatively set at one-quarter. Salaries make up about 60 percent of all university expenditure, so we arrive at an estimated figure for research of £A3 million for 1958–59, which probably errs on the generous side. The total research expenditure for 1958–59, then, was £A4 million ($9 million). Full-time university staffs in that year numbered about 2000.

A number of university research establishments have been set up by public agencies or by private benefaction, the universities being thus relieved of the burden of capital expenditure. In such instances the head of the institute is often a professor of the university. In other instances the work of a university laboratory may be supported by private or public funds. An interesting case is the Nuclear Research Foundation, which has raised money from both private and public sources to support the work of the School of Physics at the University of Sydney. The Biochemistry School at the University of Melbourne has benefited in recent years from grants made by food-processing firms. Research at the University of Melbourne into the production of town gas from lignite, which occurs in vast deposits in the state of Victoria, is supported by the Gas and Fuel Corporation, a state-government agency. It should be emphasized, however, that this is not the equivalent of "contract research," which is not common in Australia. In this respect Australian universities follow the British pattern rather closely (*8*).

The Commonwealth Scientific and Industrial Research Organization. The CSIRO is by far the largest and most important research body in Australia, dating from World War I. In 1916, the federal prime minister, W. M. Hughes, visited Britain and was stimulated by the British government's action

in setting up the Department of Scientific and Industrial Research to establish a similar organization in Australia. An Advisory Council for Science and Industry was established, and by an act passed in 1920 a permanent body was set up, called the Institute of Science and Industry. The institute had an annual budget of only £A25,000, and most of its activities were devoted to supporting research in the universities. In 1925 a conference of scientists was called to discuss the reconstitution of the institute, which became, in 1926, the Council for Scientific and Industrial Research (CSIR).

The initial budget of the new organization was £A45,000, and the amount rose slowly until the last few years before the outbreak of war in 1939.

Until 1938, CSIR's research program was concentrated on problems relevant to primary industry. With the approach of war, the industrial side of its activities expanded rapidly and made possible the local production of many industrial items that previously had been imported (*9*). In 1939, CSIR had a budget of £A350,000 and a total staff of 400. In 1946–47 the budget had risen to £A1.4 million, and the staff to 2300.

In 1949, CSIR was again reconstituted by act of parliament and given its present name of Commonwealth Scientific and Industrial Research Organization (CSIRO). Among changes made at this time were the transfer of its activities in defense research to other government agencies. In 1959 the act was amended to allow further organizational changes. Administratively speaking, CSIRO is a public corporation and thus has greater freedom of action than a normal department, especially in regard to financial management, staffing, and ministerial control (*10*). Like most public corporations, it is administered by a board, called in this case the Executive, whose members are appointed for terms specified in the statute and can be removed only for cause. The 1959 act provides that the Executive shall consist of five full-time and four part-time members, and that five members must be scientists.

The functions and expenditure of CSIRO have continued to grow apace. By 1958–59 its expenditure was £A8.5 million ($19 million) and its staff had grown to 4000, of whom over 1300 were classified as "research" and "experimental" officers. Its activities are now distributed among 27 divisions and 17 smaller "independent sections." There are divisions of animal research, building research, industrial chemistry, plant industry, fisheries, food preservation, entomology, forest products, electrotechnology, radiophysics, soils, solid-state physics, and wool research, among others.

CSIRO has also entered into cooperative research arrangements with industry, on lines similar to the "research associations" set up by the Department of Scientific and Industrial Research in Britain, with both parties contributing to the cost of research, usually carried on in laboratories set up for the purpose. The research staff is mainly provided by CSIRO, and information is made available to the industry concerned under an agreement with CSIRO. Four such institutes are currently in operation, for the bread, wine, coal, and tobacco industries; a research association for the leather industry was recently dissolved. CSIRO also carries out research at the request of industrial firms, which normally provide funds to cover the cost of the particular investigation, and at the request of government agencies, both federal and state. In 1958–59 CSIRO received a total of more than £A200,000 in this way, mostly from public sources. An example of a more formal arrangement is the program undertaken by CSIRO in the important Murrumbidgee irrigation area in southern New South Wales, where the work of the research station is supervised by a joint committee representing CSIRO, the local farmers, and the New South Wales Water Conservation and Irrigation Commission.

Although complaints have sometimes been made in university circles that CSIRO has a "monopoly" of research, the relations between CSIRO and the universities have been close and generally cordial (*11*). Not only is there considerable interchange of personnel between CSIRO and the universities, but contact has been facilitated by the establishment of a number of CSIRO laboratories on university campuses. In some cases the heads of such laboratories are professors of the university; in others, senior members of the laboratory staff have been given honorary university appointments, with the rank of associate professor.

In view of the importance of the wool industry to Australia it is not surprising that CSIRO's activities have had particular relevance to woolgrowing. Between 1945 and 1959, wool production increased by 50 percent—an increase made possible largely by CSIRO discoveries. Research on pasture improvement brought about a 100 percent increase in high-quality pasture in the decade 1948–58, and the successful program of rabbit control that followed CSIRO's work on myxomatosis brought about a spectacular rise in the sheep population during the same period. In spite of this, the woolgrowers have not shown themselves eager to contribute financially to wool research, apart from making a few large individual gifts to the Science and Industry Endowment Fund, established by act of parliament in 1926. This situation has changed only very recently. About 15 percent of CSIRO's annual income now comes from the Wool Research Trust Account, established by the federal government in 1945. This fund originally consisted of undistributed moneys from the sale of wool during the war (when sale of wool was completely under government control) and from the sale of wool by the joint organization set up by the wool-producing countries and Great Britain to dispose of accumulated stocks at the end of the war. The continuing income of the Wool Research Trust Fund comes from a levy on each bale of wool sold. Originally, 2 shillings per bale, paid by the growers, was to be used for sales promotion, and an equal amount paid by the government was to be used for research. These amounts were later doubled. In 1960, the woolgrowers agreed, under pressure from the government, to raise their contribution to 5 shillings per bale for promotion, and to pay 2 shillings per bale in addition for research; the government's contribution remains at 4 shillings per bale for research.

Defense research. Research and development in connection with guided missiles, aircraft, and other weapons are concentrated almost entirely within the Department of Supply and Defense Production. This department, whose functions date entirely from World War II, has three main research divisions: the Defense Standards Laboratories, the Weapons Research Establishment, and the Defense Research and Development Laboratories. The Weapons Research Establishment, where the pilotless aircraft known as "Jindivik" and "Malkara" were developed, was set up in 1947, in conjunction with the British Ministry of Supply (now the Ministry of Aviation),

whose contribution to the cost of the Weapons Research Establishment is not included in the figures given here. In 1958–59 the total expenditure of the Department of Supply was £A11.7 million ($26 million), and the total number of scientific, experimental, and engineering staff members was 635. Officers of the scientific and experimental staffs are organized within the Australian Defense Scientific Service, whose system of classification and terms of employment are based on those of CSIRO.

A few years ago the Royal Australian Navy established an experimental laboratory. This remains a small establishment, whose expenditure in 1958–59 was £A70,000.

Atomic energy. Australia's interest in atomic energy originated with the discovery of radioactive minerals. Prospecting for uranium was begun in 1944 at the request of the British government, and the first extensive deposits were found in 1949. In 1946, the Atomic Energy (Control of Materials) Act gave the federal government control of radioactive minerals under its defense power. Advisory committees were established, and in 1952 the Atomic Energy Policy Committee recommended that a new operating organization be set up. This recommendation was made in response to a request from the Combined Development Agency in Washington that uranium production be expanded, and the Australian Atomic Energy Commission, established by act of parliament in 1953, was for several years concerned mainly with this problem. In 1954 the commission decided to set up its own research establishment, and a site was chosen at Lucas Heights, near Sydney. The nucleus of staff for the research program came from CSIRO and the Supply Department.

The Australian Atomic Energy Commission is also a public corporation, administered by a board of five members, one of whom is a full-time member. Its structure was slightly altered by a subsequent act, passed in 1958. Although it has control over its own staff, its research personnel are employed under conditions similar to those for CSIRO.

The first reactor to be installed at Lucas Heights was a research reactor of the DIDO type, known as HIFAR (high-flux Australian reactor). It has been in full operation since 1958. HIFAR is primarily a materials-testing reactor, but it is used also for the manufacture of radioisotopes. The metallurgical and chemical behavior of reactor materials under extreme conditions of radiation and temperature are being investigated. Early in 1960 it was announced that a second low-power reactor of the high-temperature, gas-cooled type would be installed. This new reactor will be characterized by its use of a mixture of fuel and moderator, and its extensive use of beryllium as fuel "can," moderator, and reflector. It will be used to investigate the U^{233}-thorium fuel cycle instead of the more common plutonium-U^{235} cycle.

Between 1955 and 1959 the commission spent more than £A13 million ($31 million), and its expenditure in 1958–59 was £A2.7 million ($6 million). In 1959, research and engineering staff numbered 165; total staff, 484. With the rapid expansion of research activities, these numbers will probably double within 3 years.

The commission has let a small number of research contracts to universities and hospitals and has also undertaken other forms of cooperation. It was responsible for the installation of a cyclotron at the University of Melbourne in 1955; research is conducted by members of the university staff. The commission has also established, in conjunction with the universities, an Institute of Nuclear Science and Engineering, with headquarters at Lucas Heights. The institute will be mainly concerned with administering a scheme of fellowships for research in nuclear energy.

Health. In the field of health, the federal constitution gives the Commonwealth power only over "quarantine," but in 1925, after the report of a royal commission, a Federal Health Council was set up representing both the Commonwealth government and state governments. In 1936 this was replaced by the National Health and Medical Research Council, which comprises the permanent heads of the state and federal health departments, together with a number of experts. In 1937 an act was passed setting up the Medical Research Endowment Fund, financed by an annual appropriation, to assist government departments, universities, institutions, or persons carrying out medical research. A small number of scholarships is also offered annually. Over 50 institutions have been approved for grants, and £A210,000 was expended by the fund in 1958–59. In addition to this federal aid, a number of state-supported and of privately endowed medical research projects are in existence.

The Commonwealth Health Department also operates a number of laboratories, including the Acoustic Laboratories, the X-Ray and Radium Laboratory, Biological Standards Laboratories, Dental Standards Laboratories, Commonwealth Serum Laboratories, and the School of Public Health and Tropical Medicine. In 1958–59 the total cost of these activities was approximately £A1.5 million ($3.4 million), and the total staff of medical and scientific officers was 240.

Miscellaneous. A small amount of research is done by state-government agencies such as museums, forestry departments, and the like, in addition to state-government research in agriculture. In 1958–59 the states spent approximately £A10.5 million on agriculture, £A5.5 on "science, art and research" (the official statistical category), and £A5.5 million on forestry. Agricultural research accounts for an estimated £A1.5 million, so the total figure for state research expenditure is probably between £A2 million and £A2.5 million.

Research activities are also carried out by Commonwealth departments such as the Bureau of Meteorology, the Forestry and Timber Bureau, the Ionospheric Prediction Service, and the Bureau of Mineral Resources. The total expenditure of these agencies in 1958–59 was more than £A3 million ($7 million), and their total staffs numbered nearly 500.

Expenditure by Industry

For the reasons already indicated, private industry has not made any notable contribution to research in Australia, and its backwardness has been the subject of frequent criticism. Although the rapid growth of industry since 1939 has brought a greatly increased demand for scientists and technologists, the Murray committee observed that the need for greater effort in research had been "expressed by the development of government agencies such as CSIRO, rather than by the participation of private industry in research and development . . . individual companies, with a few notable exceptions, have shown little tendency

Table 1. Commonwealth government expenditures for research, 1958–59.

Agency	Amount (£A, millions)
CSIRO	8.5
Supply Dept.	11.7
AAEC	2.7
Health Dept.	1.5
Bur. of Mineral Resources, Bur. of Meteorology, etc.	3.0
Total	27.4*

* $62 million.

to provide for their own research needs or to foster the establishment, on a co-operative basis, of industrial research associations" (*12*).

Partly because industry's research effort is still limited, data are scanty, and only an incomplete picture can be given here. The main branches of industry in which research establishments exist, apart from the institutions set up cooperatively with CSIRO, are steel, chemicals, sugar, pharmaceutical products, paper and pulp, food processing, electronics, gas production, nonferrous metals, and textiles. The largest effort is to be found in the steel industry. Iron and steel production in Australia is monopolized by one large industrial complex, the Broken Hill Proprietary Company Limited, whose activities have expanded greatly since the war. In the five years ending in 1956, the company invested £A60 million ($135 million) in steel production and planned to double the amount in the succeeding five years. Its total output of iron and steel products has more than doubled since 1939. In 1955 the company embarked on a research program which has involved a capital cost of over £A400,000 ($1 million) to date, and its annual expenditure is now about £A100,000. It employs about 90 scientists, engineers, technicians, and geologists. The sugar industry is also dominated by one large concern, the Colonial Sugar Refining Company Limited. The company's activities extend into other branches of secondary industry, especially chemicals and building materials. The total annual expenditures of CSR's own laboratories, and of those of other establishments in the sugar industry, is now about £A500,000 (*13*).

On the basis of this information and a few other scraps of data which are available (*14*) it can be said with some assurance that the total amount spent by industry under present conditions does not exceed £A5 million ($13 million) annually. Almost all of this is for "development" rather than "research." Some reasons for this backwardness, apart from the general background already sketched, may be suggested briefly. The relatively small scale of much of Australian industry is one important factor, since size of firm is highly correlated with research effort. Second, a large number of local enterprises are subsidiaries of overseas firms, predominantly British but also American. In such cases, techniques developed by the parent firm are applied with little change, although in some cases a modicum of "development" is required to bring the product into line with local needs. There may be some justice in the assertion sometimes made that the much-advertised backwardness of British industry in the field of research has its effect on British-owned firms in Australia. It is true that, in many cases, industrial firms are more likely to ask for tariff protection against imported manufactures from Europe, Japan, or North America than to embark on developmental schemes to make their products more competitive. As the effect of such protection is usually to increase prices, the Commonwealth government has perpetually to weigh the cost of living against the advisability of encouraging local industry. The volume of industrial research carried out by CSIRO has from the beginning, and increasingly in recent years, been part of a general attempt to improve industrial efficiency and thus reduce the need for tariff protection. The work done by CSIRO that is of direct or indirect benefit to manufacturing industry is still much more important than industry's own research effort, and CSIRO's discoveries are readily available. It recently established an industrial liaison branch to promote the use of new techniques by industry. Only a few CSIRO discoveries have been patented (for example, processes for making woolen textiles); in such cases the patent belongs to CSIRO and only small fees are charged.

Tabulation of Expenditure

All figures given in Tables 1 and 2 relate to the budgetary year 1958–59. In that period the Commonwealth government spent directly a total of £A29 million ($65 million). (This excludes expenditure in the form of university and other grants.) The breakdown of this amount, in terms of the spending agencies, is given in Table 1.

Table 2. Aggregate of private and public expenditure for research, 1958–59.

Sector	Amount (£A, millions)
Commonwealth government	27.4
State governments	2.5
Universities (estimated)	4.0
Industry (estimated)	3.0 to 5.0
Total	37 to 39*

* $83 to $88 million.

Table 2 attempts to give a total picture for the same year. In both cases, the amounts are linked with the spending body and not with the original source of funds. Duplication has been avoided as far as possible.

This estimated total represents approximately 0.6 percent of gross national product for the budgetary year 1958–59, as compared with National Science Foundation data which give the U.S. figure as something over 2 percent. (Whether these figures are strictly comparable is, of course, not certain.) In the same year the number of people employed in research and development work, if we exclude university teaching staffs, was probably in the vicinity of 4000; of these, about 3000 were employed by the Commonwealth government.

Research and development occupied a significantly larger part of the federal budget in 1958–59 than it did in 1939. In 1938–39, the Commonwealth government allotted only 0.5 percent of its expenditure from consolidated revenue to research and development; in 1958–59, out of a total expenditure of £A1,300 million from consolidated revenue, the proportion had risen to 2.2, with grants to other bodies not included.

Civil, nonmedical, research accounted in 1958–59 for a total of £A24.5 million ($55 million). About one-quarter of this amount was spent on research connected with the agricultural and pastoral industries. To attempt a further breakdown into "basic" and "applied" research would be an unprofitable exercise. It may be observed, however, that because of the preponderance of governmental research institutions like CSIRO, where scientists are fairly free to define their own problems, a relatively large proportion of "basic" research is represented in the general picture.

References and Notes

1. See N. Butlin, "Colonial socialism in Australia," in *The State and Economic Growth*, H. G. J. Aitken, Ed. (Social Science Research Council, New York, 1959), for a historical analysis of state economic action.
2. J. D. B. Miller, *Australian Government and Politics* (London, ed. 2, 1958), pp. 200 ff.
3. For a discussion of this point see S. Encel, *Australian J. Politics and History* **6**, No. 1 (1960).
4. The "export of talent" is bitingly discussed by a leading zoologist, A. J. Marshall, in a wartime pamphlet entitled *Australia Limited* (Sydney, 1942).
5. In 1959, the Commonwealth government decided to amalgamate the Australian National University with the Canberra University College, a small teaching institution set up in 1930, most of whose students until recently were civil servants taking part-time courses. The Australian National University, as reconstituted by an act passed in 1960, consists of an Institute of Advanced Studies and a School of General Studies.
6. These and other figures, unless specifically indicated, are drawn from the annual budget papers and from the official *Commonwealth Yearbook*.
7. This problem is discussed by J. Gani and A. Blakers, *Universities Quart.* **1959**, No. 1 (1959) and *Scientific and Technical Manpower in Australia* (Australian Academy of Science, Canberra, 1957).
8. An analysis of the sources of university research funds in Britain is to be found in G. L. Payne, *Scientific and Technological Manpower in Great Britain* (Stanford, London, 1960).
9. D. P. Mellor, in *Official History of Australia in the War* (Sydney, 1957).
10. See G. Sawer, in *The Public Corporation*, W. Friedmann, Ed. (Toronto, 1954), and S. Encel, *Public Administration* **38**, No. 3 (1960).
11. See *Science in Australia* (Australian National Univ., Canberra City, 1951) for a discussion of these and related problems.
12. *Report of the Committee on Australian Universities* (Canberra, 1957), pp. 27–28.
13. See A. G. Lowndes, Ed., *South Pacific Enterprise* (Sydney, 1958), for an account of the company's activities.
14. In 1955 the Institution of Engineers, Australia, surveyed 104 large firms with an annual output of £A500 million, and found that they spent £A1.7 million on research and development; this amount represented 0.3 percent of turnover.

Arnold L. Gesell: "Behavior Has Shape"

"In countless American homes the name of Arnold L. Gesell was better known than that of the President of the United States. And to great numbers of the occupants of those homes Arnold Gesell was a far more important man than the occupant of the White House. . . . His work over many years in the fields of pediatrics and child development paved the way to health and success for thousands, mayhap millions. Dr. Gesell was a pioneer, one who traced uncharted paths to charted conclusions." So commented an editorial in the New Haven *Register* at the time of Gesell's death on 29 May 1961.

The application of his findings to the everyday child in the everyday home was the fruit of half a century's painstaking study—half a century of careful analysis of the behavior patterns of human infants and children as these patterns grew and changed with the child's increasing age.

A single central concept—brilliant in its simplicity and one to which he clung in the face of often strong opposition—was the basis of all of Gesell's work on age levels from fetal ages on through adolescence. This was the concept that developing behavior has as much structure as does the developing physical organism, that behavior develops in a patterned, highly predictable manner, and that it is measurable. "Behavior has shape. Mind manifests itself." These are two statements which his students and colleagues were to hear over and over again.

While environmentalists were going to great lengths to measure the extent to which environmental forces determine behavior and even individuality, Gesell reminded us again and again that "environmental factors support, inflect, and modify, but they do not generate the progressions of development. Growth is an impulsion, and a cycle of morphogenetic events is uniquely a character of the living organism."

Gesell's first work at Yale, in 1911, when he founded his clinic which after several changes of name came to be known as the Yale Clinic of Child Development, was with retarded school-age children. However, at that time he was "in auditory communication at least," as he used to say, with a well-baby clinic across the corridor. And very soon he began to feel that the place to start a study of human behavior was with infants, and with normal infants at that.

And so for 20 years he carried on a painstaking and step-by-step analysis of infant behavior, chiefly as expressed in normatively controlled test situations as these infants responded to simple stimulus objects such as cube and pellet and bell. From this analysis he not only established the fact that infant behavior does develop in a patterned, orderly manner through stages which are alike in quality and sequence (even though not in exact time of occurrence) from child to child, but also described these stages.

Gesell tracked down the patterned behavior changes in infant and child through the age of 16 years—an endeavor which he completed in 1956 with the publication of *Youth: The Years from Ten to Sixteen*. From this base, the application of his findings spread into two widely diversified fields.

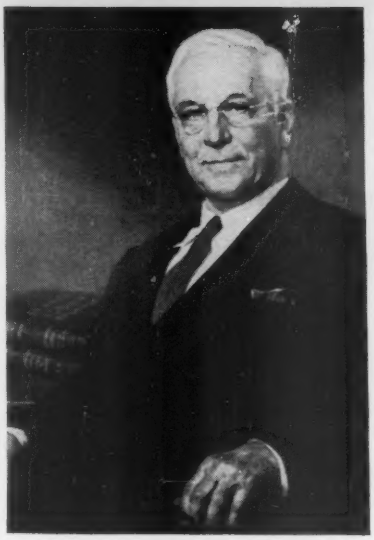
Clinically these findings were applied in the field of practical pediatrics. Gesell was perhaps the first to insist that "development as well as disease lies clearly in the province of clinical pediatrics." It was largely as a result of his untiring efforts that in the early 1940's the American Academy of Pediatrics changed its admittance examination to include a section on the development of infant behavior. Many pediatric clinics now quite routinely give the Gesell Developmental Tests to infants and preschool children in an effort to determine not so much their I.Q. as their D.Q. (developmental level or developmental quotient). In his last ten years at Yale, Gesell and his staff trained pediatricians not only from all over the United States but from all over the world (in fact his work at times found more ready acceptance in European countries than in our own). Gesell considered that the developmental examination was in fact a neuro-

logical examination and that, especially in cases of defect and deviation, it could give a valid indication of how far behavior had developed.

The impact of his work in a second main area stemmed from his direct contribution of a clear and simple description, for parents, of behavior characteristics of successive age levels from infancy through 16 years of age. He described behavior for each age level in terms not only of all the things a child can do at that age but of special characteristics of that age. Noteworthy was his finding that, in accordance with a principle of reciprocal neuromotor interweaving which he emphasized, ages of equilibrium and of disequilibrium, ages of flexion and of extension, ages of inwardized and of outwardized behavior tend to alternate.

Gesell's extreme productivity during an unusually long career (after his retirement from Yale he worked actively as research consultant at the Gesell Institute, founded in his honor in 1950, until he was 78) is evidenced by a bibliography of his writings, which at the time of his death at 80 included well over 400 items. Among his best-known books were *The Mental Growth of the Preschool Child* (1925); *Psychology of Early Growth* (1938); *Atlas of Infant Behavior* (1934); the trilogy *Infant and Child in the Culture of Today, The Child from Five to Ten*, and *Youth: The Years from Ten to Sixteen* (1943–1956); *Embryology of Behavior* (1945); *Developmental Diagnosis* (1941); and *Vision: Its Development in Infant and Child* (1949). These and his many other books were translated into more than two dozen different languages.

His scientific articles covered a wide variety of fields, including retardation, cerebral palsy, cretinism and mongolism, visual deviation, and twinning, as well as behavior of normal infants and children. All, however, dealt with the central theme of the measurable growth of behavior and of behavior deviation.



Arnold L. Gesell

A method of analysis which he did much to further was the use of motion pictures in the study of child behavior. In 1925 he started the collection known as the "Yale Films of Child Development." Pictures were taken in the now well-known Dome, and miles of systematically exposed film, both 16- and 35-millimeter, were gradually made available for the analysis of behavior patterns and for editing and use as teaching and demonstration films. Gesell was also, so far as is known, the originator of the one-way-screen method of observation now so widely used.

The flexibility and wide application of the developmental point of view is evidenced by the fact that it has turned out to be uniquely useful in fields which were scarcely thought of when Gesell began his work—such widely divergent fields as that of vision in infant and child and that of the projective techniques—two areas in which he did a considerable amount of effective work toward the end of his long career.

It was an ironical matter of timing that much of Gesell's work was done against the current of a very different theory of child behavior prevalent in this country during the period of his investigations. The atmosphere at Yale's Institute of Human Relations in the 1930's was hardly favorable to his developmental philosophy, and the emphasis on psychoanalysis that dominated the behavior sciences in the 1940's was no more propitious. This relative isolation from certain groups of his fellow scientists gave strength and unity to Gesell's work but possibly prevented his theories and findings from having the impact on many child psychologists that they had on practicing pediatricians and on the public.

Nevertheless, by 1956 Helen Puner could write in an article that appeared in *Harper's* in March of that year: "Now in the late fifties, 'constitutional factors' and 'the nature of the baby' are being mentioned and written about once again . . . It is beginning to be recognized that Dr. Gesell was correct in his belief that 'personality cannot be understood as a direct reflection of its shaping force . . .' In fact it may easily be that Dr. Gesell's aim—if not his point of view—has not been so much behind the times as ahead. For today it is he, and he alone, who has built up the only systematic body of observations on the development of human behavior and personality."

LOUISE BATES AMES
Gesell Institute of Child Development, New Haven, Connecticut

Science and the News

The School Bill: Notes on the Political Situation

The famous House Rules Committee became a bit more famous last week. In mid-June two of the three Catholics on the committee joined with the seven conservatives to form a 9 to 6 majority against considering the school bill. What they wanted was a companion bill containing a program of loans for parochial schools. The Education and Labor Committee dutifully produced an amended National Defense Education Act containing such a program. The Rules Committee then decided against sending either bill to the House floor for a vote, Mr. Delaney, of Brooklyn, having concluded that the loan program was "just a sop." Mr. O'Neil, of Massachusetts, returned to his normal position as a supporter of the Administration, but Delaney plus the seven conservatives made the vote against the education bills 8 to 7. It was a most peculiar situation. Mr. Delaney and Mr. O'Neil were widely and loudly denounced for holding the school bill up for ransom. The Administration was more mildly and less widely denounced for putting up the ransom. Then Mr. Delaney decided he did not care for the ransom after all, and that he would rather kill the baby.

All of this was curious, but its real effects have been exaggerated. The Rules Committee action was widely reported to have killed the school bill. The school bill may well be killed, but the reports last week that it was already dead were, at the least, premature.

Committee Action

The Rules Committee action, barring an unexpected turnabout by Delaney, means that the school bill cannot reach the floor of the House by the normal route of getting a resolution from the committee sending it to the floor for debate. On an issue on which the House is as closely divided as it is on this one, this would normally foreclose any realistic possibility of the bill's reaching a vote. There are several methods of bypassing the Rules Committee, but all of them are awkward and easily frustrated unless there is a strong majority in the House in favor of the bill. There is no such ready-made majority for the school bill.

On the other side, there are two factors which could pull the bill through despite all obstacles. The Administration, knowing from the start that it faced an uphill battle on the school bill, had the foresight to tie together the intensely controversial new school-aid proposal with an entirely noncontroversial proposal for renewing an existing program of federal aid to what are called "impacted areas." The impacted areas are school districts where the amount of untaxable government property makes it difficult for the district to finance its schools. If a private company builds a factory in a town, the town levies property taxes on both the factory and the homes of the employees to pay for schools for the children of the employees. If the government establishes an army base in a town, the base cannot be taxed, and homes of the servicemen who live on the base cannot be taxed. This problem led to the impacted areas program, where the government gives grants of money to the school districts in lieu of the taxes they would have levied if the property were privately owned. The program is very widespread: three out of four members of Congress have impacted areas in their districts. On the average, each of these Congressional districts receives $1 million a year in direct federal school grants. The program expired 30 June. It is an understatement to describe the pressure of the 319 Congressmen from such districts to see that the program is renewed as intense. As long as the supporters of the general school bill can succeed in keeping general aid to schools tied to the impacted areas program, a bill containing both cannot be considered dead.

The impacted areas program therefore gives the school bill's managers a good deal of leverage. Under the right circumstances, it might be sufficient to get a general school aid bill through the reluctant House. Getting the right circumstances depends partly on questions of timing, partly on how fully the President is willing to commit himself to the fight. These two factors are related. Both point toward delaying a showdown on the school bill until the closing days of the Congressional session. Aside from the question of the President's role, the best time to bring about a showdown will be when the country is thinking about schools, which will be at the very end of the summer, or in September, when the school year is about to begin. Delaying the showdown will also make it easier for the President to play a major role in the controversy.

Next week the Senate will take up the major item on Kennedy's legislative program, the foreign aid authorization, and this issue will dominate the debates on Capitol Hill well into August. This is the one controversial issue where there not only is no Congressional resentment at the President's going to the people to pressure Congress into supporting him, but where Congress expects to be, indeed wants to be, publicly pressed by the President. Congress expects the President, acting as national leader, to tell the country why foreign aid is necessary and thus make it easier for individual Congressmen to vote for it. But this makes it awkward for the President to be simultaneously active on both foreign aid and the school bill. On one issue he must be wholly above domestic politics; on the other he cannot help being deeply immersed in it. Both cannot be done simultaneously with full effectiveness, and thus it will be difficult for the President to play a very active role on the school bill until the foreign aid bill has been settled, which will probably be sometime in middle or late August.

Delay Indicated

The indicated strategy, then, for supporters of school aid is to drag their feet and delay a showdown. For opponents of school aid the strategy is to try to force a showdown as soon as possible. The outlines of the tactics for both sides began to take shape last week almost immediately after the Rules Com-

mittee action. Opponents of the school bill introduced bills to extend the impacted areas program separately from general school aid. Chairman Powell of the Education and Labor Committee announced that his committee was not going to report such a bill. The opposition filed what is called a "discharge petition" to bring an impacted areas bill to the floor of the House without action by the Education Committee. This will require the signatures of 219 members, a majority of the House. The aim of the Administration will be to try to keep members who are supporters of both general aid and aid to impacted areas from signing the discharge petition, at least until the Administration is ready to deal with the question.

Supporters of the school bill hold an advantage in tactical position that is normally held by their opponents. Congressional procedure makes it far easier to delay something controversial than to speed it up, and in this case it is the liberals rather than the conservatives who are in no rush to act. If the discharge petition succeeds and a separate impacted areas bill is put through the House, a showdown can still be delayed until it is convenient for the Administration. In the Senate, supporters of school aid appear to be in full control. This makes it unlikely that a bill covering only impacted areas would get through the Senate. The House could then ask for a conference to work out a compromise between the House bill and the bill the Senate has already passed, which includes the controversial general aid as well as impacted areas aid. But the conference could then be stalled for whatever supporters of school aid feel is an appropriate length of time, at which time the conferees could report a compromise bill embodying most of what the Administration wants.

The real problem of supporters of the school bill is to get the House to accept a conference report containing the Administration proposals. This will be a difficult task, as everyone has known it would be all along. The Rules Committee action last week added a bit more flavor to the elaborate game of high politics that will decide the fate of this bill, but it never was likely to be decisive. For if, with the leverage available through the impacted areas program, the Administration lacked the strength to force a bill to a vote despite the Rules Committee, it almost certainly would have lacked the strength to push the bill through the House even if the Rules Committee had cooperated. Indeed the Rules Committee may even have helped a bit, for now if the bill does reach the floor, it will not do so as part of a widely publicized and widely criticized bargain with the parochial school bloc.

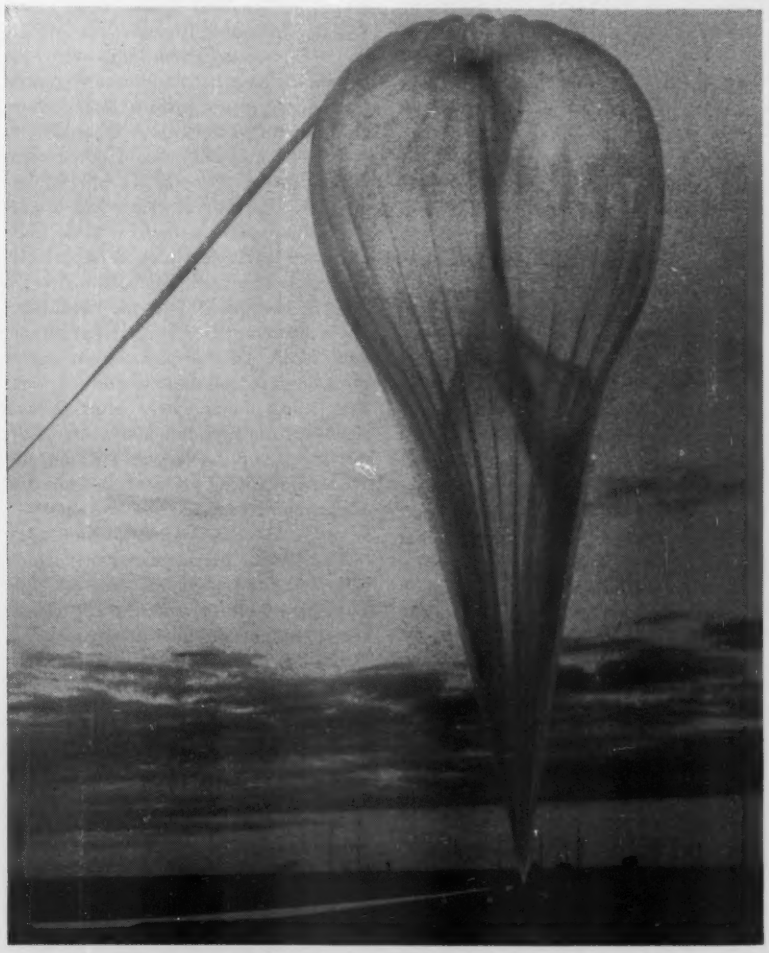
As for the outcome, a great deal depends, as has been widely noted, on what the President is prepared to do. What the President does depends a good deal on what the general political situation will be in September and, to a large extent, on whether he feels that anything he could do would be enough to carry the day. At this point it is the critics of general school aid who are glowing with optimism, and it may turn out that their optimism is justified.—H.M.

News Notes

Project Banshee

Weather and winds finally permitted this week the first in a series of 10 firings in Project Banshee, the Department of Defense research program to study the blast-wave effects of explosives detonated from balloons at 38,000 to 115,000 feet. The way was cleared for the actual firings to begin when, after five trys, the second dry run was successfully made last week.

The balloon (see cut) was launched into a high-altitude wind stream that carried it and its 200-foot train of instruments and 500 pounds of conventional high explosives over the 4000-square mile White Sands Missile Range in the New Mexico desert. Air Force planes



Banshee balloon: the plastic balloons vary in size according to altitude desired. Some are as long as a football field. [Department of Defense]

flew a safety chase on the balloon while ground-based tracking instruments also kept it under surveillance until it was in position for safe detonation. The charge was exploded at a signal from the ground, and the package of instruments dropped back to earth via a standard 64-foot orange and white cargo parachute.

After the series of firings has been completed, another set of these balloons will be used as targets for Nike-Hercules ground-to-air missiles with high-explosive warheads, in place of the nuclear warheads that would be used in combat.

The measurements obtained from both phases of Project Banshee will make it possible to estimate the possible damaging effects from nuclear explosions at high altitudes.

Drinking Water Standards

The first major revision by the Public Health Service of Drinking Water Standards for the United States since 1946 includes, for the first time, limits on concentrations of radioactivity and certain chemical pollutants.

Radioactivity in water, on the basis of recommendations by the Federal Radiation Council, the National Committee on Radiation Protection, and the International Commission on Radiological Protection, is now limited to 3 micromicrocuries per liter for radium-226, 10 micromicrocuries per liter for strontium-90, and 1000 micromicrocuries per liter for gross beta activity. The recommended maximum daily intake for Ra^{226} is 7.3 micromicrocuries, and for Sr^{90} it is 73 micromicrocuries.

In setting the relatively high limits for Ra^{226} and the lower limits for Sr^{90}, consideration was given to the fact that most radiation from Ra^{226} is in water and most radiation from Sr^{90} is in food. The gross beta activity is relied on only when alpha (in this instance Ra^{226}) content and Sr^{90} content are low enough to be insignificant. The PHS also took into account high levels of naturally occurring radioactivity in some water sources. If in some instances these should show higher radiation levels than those recommended, an evaluation of total intake would be made of radiation from food and air. Should this prove to be too high, the water source might have to be condemned and less-radioactive water would have to be imported by the communities involved. However, in the absence of above-ground nuclear testing and the substantial increase in Sr^{90} that might result, it is unlikely that water will be condemned for excessive radiation.

Chemical pollutants not previously limited in water include alkyl benzene sulfonate (detergents), barium, cadmium, carbon, chloroform extractables, cyanide, nitrate, and silver. The growing problem of potentially harmful chemicals in sources of drinking water is recognized, but PHS does not find it necessary at this time to include limits for all potentially toxic chemicals.

Drinking Water Standards originally were set in 1914 and have provided the basis for legally regulating drinking water used on trains, airplanes, buses, and vessels in interstate commerce. They have served as guides for control of water supplies generally throughout the country, affecting more than 125 million people.

Tariff exemption for electron microscopes and medical equipment in which a radiation source is used went into effect last week. Exemptions for this equipment have been commonly granted in the past, in the form of special laws allowing duty-free import of a specific piece of equipment. Confronted with half a dozen requests for special exemptions, the House Ways and Means Committee decided there was no need to review each new request separately. The committee recommended writing a general exemption into the tariff law, applicable to imports by nonprofit organizations. The bill passed both houses of Congress without opposition and took effect immediately after it was signed by the President last week. Without the exemption the tariff would add 50 percent to the price of an imported electron microscope.

The special presidential panel which is studying the possibility that the Russians have been or could be engaged in **secret testing of nuclear weapons** is chaired by Wolfgang Panofsky, professor of physics at Stanford. The White House announced the membership of the committee last week. The panel was appointed about a month ago. Panofsky, a member of the President's Science Advisory Committee, has been in the news recently as chief scientist on the $114 million Stanford electron accelerator, construction of which is expected to be authorized by Congress next week. The panel met with the President last Friday to give a report on its findings, but the White House said that Kennedy had asked for further details and that the study probably would not be completed for several more weeks.

Kennedy's request for an **accelerated space program** has received top-heavy endorsement from Congress, which authorized $1.7 billion for the current fiscal year, the full amount Kennedy requested. This is about 60 percent more than Eisenhower had recommended and about double what was spent last year. The Administration had warned that it would be wasteful for Congress to authorize the full amount unless it was prepared to follow through and vote the even larger sums, over $2 billion a year, that would be required in the future. The actual appropriations will be made in a later bill, but the lopsided votes (354 to 59 in the more conservative House) suggested that the appropriation bill would come quite close to the full authorization.

On the **communications satellite program**, Kennedy issued a policy statement announcing that "private ownership and operation of the U.S. portion of the system is favored, provided that such operation meets [certain] requirements." Among these requirements are that the system must be world wide and that access to shares in the ownership and use of the system must be available to all countries. Kennedy also said that "to date, no arrangements between the government and private industry contain any commitments as to an operations system" and that he was "anxious that development . . . proceed with all possible promptness." Background on this statement appeared in Science and the News last week.

The orbiting of American **reconnaissance satellites** constitutes an "act of aggression," according to *Red Star*, the Soviet army newspaper. The paper included in its complaint the Tiros weather satellites as well as the Midas and Samos military reconnaissance satellites. The paper compared the satellites with the U-2 flights: "It does not matter how high they fly, they are still spies," the paper asserted. "Flying a sputnik over foreign territory is an act of aggression." Under current international law, a nation's sovereignty over its air space extends indefinitely. Whether this theory can be sensibly applied to satellites outside the earth's atmosphere has never had occasion to be adjudicated. The American position is that it can not.

Announcements

Grants, Fellowships, and Awards

Travel grants for **study and research in the Soviet Union** are available to university students and scholars who wish to spend all or part of the academic year 1962–63 as participants in the academic exchange between the United States and the U.S.S.R. Applicants must have a knowledge of Russian adequate to the needs of study and research and must be U.S. citizens under 40 years of age and either graduate students, postdoctoral researchers, faculty members at the college level, or teachers of Russian in secondary schools. Deadline: *15 December 1961.* (Stephen Viederman, Inter-University Committee on Travel Grants, 719 Ballantine Hall, Indiana University, Bloomington)

Research grants in **radiological health** are available through the U.S. Public Health Service. Research proposals should contribute to the determination of the extent and character of the radiation problem as well as the mechanisms by which radiation damage is produced. (Paul F. Hahn, Office of Extramural Grants, Division of Radiological Health, PHS, Washington 25, D.C.)

Fellowships are available for graduate training related to **Latin America** in the social sciences, law, education, and the humanities for the 1962–63 academic year. The fellowships, offered by the Ford Foundation, will include Mexico, the Caribbean, Central America, and South America. They are intended to encourage the combination of multidisciplinary area training, including spoken and written language, and training in a major discipline. Deadline: *1 November.* (Secretary, Ford Foundation, Foreign Area Training Fellowships, 477 Madison Ave., New York 22)

The Bronfman prizes for **public health** achievement have been established with a grant from the Samuel Bronfman Foundation to honor "outstanding current creative work leading directly to improved health for large numbers of people." The purpose of the $5000 awards, two or three of which will be presented annually by the American Public Health Association, is to stress "application rather than discovery of new scientific knowledge" in order to "increase understanding and the appreciation of public health practice."

Applications are being accepted for the recently established Damon Runyon postdoctoral fellowships in **cancer research**, intended for the training of young investigators. Applicants who have previously held postdoctoral fellowships for 3 years are ineligible. Deadlines: *1 January*, for fellowships effective in July; and *1 July* for fellowships effective in January. (John H. Teeter, Damon Runyon Memorial Fund for Cancer Research, Inc., 730 Fifth Ave., New York 19)

Grants-in-aid for research in **petroleum geology** are being offered by the American Association of Petroleum Geologists. Emphasis is placed on the development of principles as contrasted to data-gathering or problem-solving with known techniques. Deadline: *1 January 1962.* (A.A.P.G. Headquarters, Box 979, Tulsa 1, Okla.)

Scientists in the News

Charles Huggins, director of the Ben May Laboratory for Cancer Research at the University of Chicago, and **Ludwik Gross**, chief of cancer research at the Veteran's Administration Hospital, New York, have been named corecipients of the Walker prize, presented every 5 years by the Royal College of Surgeons of England.

Karl F. Herzfeld, head of the physics department at the Catholic University of America, has received the 1960 Scientific Achievement award of the Washington Academy of Science.

Samuel Koslov, former associate professor of physics and assistant head of the department at Stevens Institute of Technology, has been appointed assistant head of Vitro Laboratories' department of physics and space sciences, New York.

Cornelius F. Strittmatter has been appointed Odus M. Mull professor of biochemistry and chairman of the department at the Bowman Gray School of Medicine, Winston-Salem, N.C., effective 15 August. **Camillo Artom**, present department chairman, will continue to serve as professor of biochemistry.

E. O. Hughes, biologist and acting chief of the National Research Council of Canada's public relations office, has been appointed scientific attaché in the Canadian Embassy, Washington, D.C. He succeeds **Harry Williamson**, who will resume his duties at NRC in Ottawa.

Ronald P. Graham, professor of chemistry at McMaster University, Hamilton, Ontario, has been selected as the first recipient of the Chemical Institute of Canada's chemical education award.

Daniel A. Boroff, bacteriologist formerly with the New England Institute for Medical Research, has been named an associate member of the Albert Einstein Medical Center's Research Laboratories, Philadelphia.

William W. Greulich, professor of anatomy at Stanford University, has been appointed science officer at the U.S. Embassy in London. He succeeds **Thomas H. Osgood**, who is returning to his post as dean of the graduate school of Michigan State University.

Kelly M. West, former associate professor at the University of Oklahoma School of Medicine, has been appointed special assistant for scientific affairs in the National Institutes of Health's Office of International Research.

Ernest Csendes, research chemist in the Pioneering Research Division of E. I. du Pont de Nemours and Company, has been appointed research director of the Armour Agricultural Chemical Company, Atlanta.

Herman F. Mark, founder and director of the Polymer Research Institute of the Polytechnic Institute of Brooklyn, has been appointed to the newly created position of dean of the faculty at the institute.

Eugene Lukacs, director of Catholic University's Statistical Laboratory, will spend the coming academic year at the Institut Statistique, University of Paris, and at the Swiss Federal Institute of Technology.

Arno S. Eklund, Swedish nuclear physicist, has been appointed director general of the International Atomic Energy Agency, Vienna. He succeeds **W. Sterling Cole**, whose 4-year term of office expires 30 November.

Space Travel Comes down to Earth

Astronomy, the so-called impractical science, has become of intense immediate concern to John Q. Public.

John B. Irwin

Space travel has changed dramatically in the past few years from a subject for idle speculation into a sharp pain in the taxpayer's pocketbook. The first sputnik in 1957—and those that followed—caused widespread reverberations in such different fields as defense, diplomacy, education, engineering, journalism, politics, science in general, and astronomy in particular. As a result, many engineers and nonscientists find themselves urgently in need of a quick education in the astronomical facts of life. There is also a growing demand for trained astronomers, ranging from experts in celestial mechanics to theoretical astrophysicists, which our graduate schools cannot even begin to meet. Ten years ago it was difficult for an astronomer to find a publisher; now, it is difficult for an astronomer to hide out from the publishers. The seven books reviewed here are all intended in one way or another to inform the general public about astronomy from a variety of points of view.

Three Popular Books

Space in Your Future, by Leo Schneider (Harcourt, Brace and World, New York, 1961. 260 pp. $3.75), is written for school children by a well-known writer who is also a science teacher. It is attractively and profusely illustrated by photographs and especially by Gustav Schrotter's line drawings. Useful lists of solar and lunar eclipses and of planetaria and astronomical societies in the United States are given in the appendixes. A considerable number of simple but thought-provoking experiments that can be performed by almost anyone are scattered throughout the book. Visits made to hypothetical astronomers at the Yerkes Observatory and the Dominion Astrophysical Observatory help to give an intimate look at the work of the professional astronomer. However, there is a debit side: the scientific reasons for space observatories, given on page 227, could be usefully amplified. The book is marred by some errors and deserves better scientific editing. For example, on page 173 we find a diagram of a slit spectograph without collimator or camera lenses; on page 177 the galactic rotation diagram is poor both as to the nature of that rotation and the relative position of the sun with respect to the spiral arms; on page 186 cosmic rays are incorrectly made a part of the electro-magnetic spectrum.

H. C. King, the author of **Astronomy** (Watts, New York, 1960. 256 pp. $4.95), is chief astronomer of the London Planetarium and has also written an excellent professional book on the history of the telescope. *Astronomy* is written for the type of audience that is attracted to planetaria; the quality of the paper is poor, however, and the quality of the illustrations, which are often garishly colored, ranges from extremely good to very poor. About one-third of the book deals with the stars and galaxies. The book should appeal to the youthful mind and may well steer many a youngster into an astronomical career.

James Stokley's **Atoms to Galaxies** (Ronald, New York, 1961. 361 pp. $6) is a very well-written popular book by an accomplished science writer who was once a planetarium director. Of particular interest in this book is a 30-page chapter on travel in space. The flavor of the writing is indicated by some of the subchapter headings: Denuded atoms, Stations in space, Nine tons to the cup, Needle-shaped dust, Radio to the rescue, The cepheids that weren't there, Out of the primeval atom, Looking backwards into time, Planets from roller bearings, and The sun's long future.

Astronomy without Mathematics

Planets, Stars, and Galaxies, by Stuart J. Inglis (Wiley, New York, 1961. 474 pp. $6.50), is an up-to-date college text written especially for students of the liberal arts and for other readers who have no mathematical or scientific background. It is very similar to many other well-organized and attractive college textbooks on elementary astronomy except that the amount of mathematics in it has been made vanishingly small. There are especially interesting chapters on the evolution of the stars and the Universe and relativity; the discussions in these chapters are of necessity rather abbreviated, and the same comment can be made concerning the author's discussion of radio astronomy and artificial satellites. Inglis gives many useful suggestions for further reading at the end of each chapter; a large fraction of these are the unusually good popular expositions found in the *Scientific American*. The most serious mistakes I found are his figure on page 378 which explains the fine structure rather than the hyperfine structure of hydrogen and on page 420 where he falls into an old trap when he states: "All distance measures are ultimately based on the heliocentric parallaxes of the nearer stars." This is not true, for example, of the derived distances for the Hyades moving cluster or for the Crab Nebula, or more important, for all cepheid distances or for all very large distances based on the luminosities of these pulsating stars. Up until quite recently the cepheid distances were based entirely upon the motions of a few close cepheids and not upon their trigonometric parallaxes or the parallaxes of any other stars.

The author is professor of astronomy at the Goethe Link Observatory, Indiana University, Bloomington.

Good Science Writing

Guy Murchie's book, **Music of the Spheres** (Houghton Mifflin, Boston, Mass., 1961. 644 pp. $6.95), can only be described as a remarkable accomplishment; it is some of the best popular science writing I have encountered, and there is scarcely a dull page in the book. It should become a best seller, especially if published as a paperback in two volumes. Although the writer has not been trained as a professional scientist, he exhibits a broad knowledge and understanding of astronomy, physics, mathematics, and the history of science. The writing is colorful and imaginative, and the author's more than 450 drawings add substantially to the reader's understanding and enjoyment. The book is in two parts: (i) Moons of Rock and Suns of Fire and (ii) Fields in Space, Deeps of Time. Five of the 14 chapter titles are: "Out from the breathing earth"; "Into the stomach of space"; "Gadflies of the void"; "The netherrealm of the atom"; "The sinews of reality." Every second page has a title of its own, and let me further illustrate both the flavor and content of the book with some choice samples: In the footsteps of the fish; Maneuvers in nothing; Crumbs of passing comets; Twenty billion cosmic snowballs; Skeleton of the galaxy; The strange emptiness within; Atom breezes that blow in solids; The birth and death of particles; The atom as a plucked string; Wisdom in the inward parts; Spectral footprints; A hole in nothing is something; Distance is a flexible dimension; Can time reverse itself?; The apple's view of Newton; Proof by weighing starlight.

Popular science writing, even at best, is often beset with fuzzy statements, exaggerations, misconceptions, errors of commission and omission, as well as misplaced emphasis. Murchie's book, excellent though it is, is not completely free from such pitfalls. For example, the exciting story of Hubble's great breakthrough, first in determining distances to the nearer spirals and then in measuring distances out to the edge of the observable universe, is not told—or explained. Humason's great observational contribution to the expansion of the universe (the red shift) is not mentioned. The author's account of Martian "canals" and "vegetation" is refreshingly conservative compared with that of many popular science writers, but I would have liked more emphasis on the fact that atmospheric oxygen has not been detected on Mars and that its *upper limit* is 1 percent of our own supply, and also on the fact that the Martian green areas are definitely not due to chlorophyll. Perhaps I am too critical on these points, but I have just read a story published in a magazine of wide circulation, in which some earthlings, who have crash-landed on Mars, apparently had not the slightest difficulty in setting up housekeeping. One wonders just how many seconds a man who forgot to bring along his own atmosphere would live on Mars. The rotation period of Venus, given as 22 hours and 17 minutes as derived from radio observations, is almost certainly incorrect. Such a fast rotation would have been measured by available optical instruments, and this planet must have a much longer period of rotation. The temperature of Venus as determined by radio astronomers is close to 600 degrees Fahrenheit; this is not mentioned. Murchie incorrectly states that all elements in the solar interior break down into protons, electrons, and alpha particles. Heavier nuclei are undoubtedly present, and their relative amounts are of critical importance in stellar interior models. Von Weizsäcker's theory of the birth of the solar system is neither as convincing nor as widely accepted as the book indicates.

On page 163 it is stated "a recent map shows every visible star out to an average distance of 2,100,000,000,000,000,000,000 miles from Mount Palomar." For the benefit of those who get lost in the zeros, this distance is 360 million light years—very roughly one-tenth of the radius of the observable universe. I know of no single star that has been observed or mapped even at 100 million light years, and there must be thousands of as yet undiscovered stars closer than a mere 100 light years. Further, a 200-inch exposure might well record more than 10 times as many "new" stars in our own galaxy as are visible on the Palomar Sky Survey, which was made with the 48-inch Schmidt telescope. Another incorrect statement refers to the supernova of A.D. 1054 (now the Crab nebula) as perhaps "the brightest celestial object, other than the sun, ever to be beheld by historic man." The author has forgotten about the moon and a number of very bright comets. In terms of *absolute* luminosity, this supernova, compared with the more than 50 other known supernovae, is one of the brightest, but many galaxies are known that are at least 10 times brighter. On page 583 Mercury's perihelion is said to be stationary in a Newtonian orbit and to advance in an Einsteinian orbit. Actually, the perihelion point advances at the rate of 573 seconds of arc a century; the rate predicted by Newtonian theory on the basis of perturbation by other planets is only 43 seconds of arc less.

Murchie proposes names for the eight fainter satellites of Jupiter: Iodama, Carmanor, Arion, Psylla, Cyrene, Antiphus, Autonoë, and Hecabe. I can only heartily agree with the comment of Seth Nicholson, discoverer of four of these moons, who is quoted as saying: "The names you suggest . . . are good logical ones. I thank that, like Pullman cars, they will be known by their numbers, not their names." He Autonoë!

Colliding Galaxies

Murchie, along with the other authors to varying degrees, does not have a completely satisfactory discussion of radio sources or, especially, of the cosmological importance of Cygnus A and similar colliding galaxies. Inasmuch as tens, if not hundreds, of millions of dollars are now being invested in instruments necessary to further investigate such radio sources, it might be well to discuss the matter here briefly. By 1952 the five brightest sources, or radio "stars," had been identified with five different kinds of objects: a pair of galaxies in collision, an elliptical galaxy with a peculiar jet, a strange object which is possibly an elliptical and spiral galaxy in collision, a supernova remnant (the Crab nebula), and an unusual new type of galactic nebula. At the present time we know (with some certainty as to their positions) of approximately 2000 radio stars; only about 70 of these have been optically identified. Perhaps only a fraction of them will ever be identified for the following reasons. Cygnus A is the second strongest known radio star, yet is at a distance of about 500 million light years and is only 18th magnitude optically. If it were four magnitudes fainter (a factor of

40), it would be almost impossibly difficult to identify or investigate with the 200-inch Palomar reflector by present techniques. Radio telescopes have increased in sensitivity so rapidly that radio stars 1/10,000 as energetic as Cygnus A will be detectable with confidence. A Cygnus A type object, other things being equal, therefore could be detected at distances 100 times greater (50 billion light years!), corresponding to a volume of space 1 million times larger. We might therefore expect 1 million such radio stars to be detectable, remembering that this is a gigantic extrapolation from vanishingly "thin" statistics. Further, Cygnus A is receding with a velocity of 5.6 percent the velocity of light, so that relativistic effects should be overwhelming at the limit of detection, and counts of radio stars to fainter and fainter limits might well give fundamental information concerning the nature of the physical universe out to distances of at least an order of magnitude larger than is possible by present optical means.

However, there is still the all-important question of the identity of these otherwise invisible sources, and for this reason every possible means should be explored to increase the sensitivity of *optical* telescopes. This could come about through image-tube devices, or more sensitive fine-grain photographic emulsions, or the discovery of observatory sites with exceptionally good seeing, or, most important, through the building of larger reflectors. The Russians are building a 236-inch reflector, possibly to be in operation by 1967; there are no corresponding plans in this country. Further, the Southern Hemisphere is poorly taken care of insofar as this problem is concerned, with nothing larger than 74 inches now available.

Measuring Large Distances

There is a strong tendency for most writers on astronomy, whether for popular or for more serious consumption, to write glibly about distances of millions or billions of light years without giving their readers a lucid and reasonably detailed account of just how such enormous distances are measured, what uncertainties are involved, or the basic assumptions that are made. A distance of 5 billion light years, close to the limit of the 200-inch telescope, is up by a factor of more than 1 million compared to the limit of trustworthy distances that can be obtained by the straightforward trigonometric method which uses the diameter of the earth's orbit as a baseline. Although an adequate account should lean heavily on drawings and pictures, perhaps the technique can be at least indicated here by a series of appropriate questions and answers: (i) How far away could the sun be observed with the naked eye? The answer is about 50 light years; this involves a knowledge of the sun's apparent magnitude and distance, the knowledge of the apparent magnitude of a barely visible star (sixth magnitude), and the use of the assumption of the inverse square law which states that the intensity of a source varies inversely as the square of its distance. (ii) How far away could a star like the sun be seen with the aid of a 200-inch telescope? About 50,000 light years. This comes from the fact that the 200-inch telescope has 1000 times the diameter of the pupil of the human eye and therefore has 1 million times the area or light gathering power; again, the inverse square assumption. (iii) How far could a large galaxy with an integrated luminosity of 10^{10} suns be seen through the 200-inch? The inverse square law is again invoked and the answer is 100,000 times further out, or 5 billion light years. (iv) What does the astronomer have to know in order to "measure" such a distance with some degree of confidence? Three things are involved: identification, photometric measurement, and calibration. The observer must be able to identify accurately a smudge on a photographic plate as a large galaxy of a given absolute luminosity. He does this by fixing his attention on a few of the brightest galaxies in a distant cluster of galaxies —each of the few dozen smudges verifying the identity and relative luminosity of each of the other neighboring smudges. The measurement is a laborious process of photometry, attempted only on those rare moonless nights of superb seeing. The light from the perhaps invisible galaxy is isolated in the focal plane of the giant reflector by a hole a few seconds of arc in diameter, accurately positioned by means of offset guiding from a brighter star. The tenuous mixture of galaxy light and night sky light is allowed to fall on a sensitive photoelectric surface, and the resulting emitted electrons are electronically counted one by one. The observer must shift back and forth all night long between the galaxy and an adjacent bit of clear sky so that the light from the galaxy can be accurately disentangled from the much more intense night sky radiation.

The astronomer then asks the key question: "How far away must this galaxy be to appear as faint as it does?" Before he can answer he must know the absolute luminosity of a large galaxy—whether it is 10^{10} suns or something smaller or larger. This involves three successive stages of calibration. The cepheid variables, those supergiant milestones of the universe, betray not only their own presence in neighboring galaxies by their characteristic variation of light but also their own absolute luminosity which increases with the period of light variation. This cepheid calibration is indirectly accomplished by statistically deriving the mean distances of nearby cepheids from their characteristic motions, or it is obtained from those few cepheids which are members of relatively nearby galactic star clusters of known distance. For galaxies of intermediate distance, such as those in the great Virgo cluster of galaxies, the cepheids are too faint to be observed, so the brightest supergiant stars in a galaxy must be used. This bright star luminosity calibration is obtained from neighboring galaxies whose distances are known because of the cepheids they contain. This large sample of intermediate galaxies of known distance (and therefore of known integrated luminosity) can then be discussed in terms of the statistics of their integrated absolute luminosities—the so-called luminosity function. The third and last calibration step enables the astronomer to predict with some confidence just what the average absolute luminosity of the 5 or 10 brightest galaxies in a cluster of galaxies will be.

The patient reader who has followed the thread of logic through all of this can readily understand how identification errors, calibration errors, statistical errors, photometric errors, and errors of assumption can enter at every stage of the game. He will not be surprised to learn that Hubble's old distance scale is off by a factor of somewhere between 2 and 15; or that a much more precise value of this factor will not appear overnight. There are other possible approaches; the apparent diameters of galaxies and also the photometry of globular clusters as-

sociated with galaxies can give useful checks. The linearity of the relation between the red shift and the photometrically derived distances gives some confidence about the internal consistency of the cosmological distance scale and also provides a useful method of determining the distance of an isolated galaxy by spectroscopic observation of its velocity; it does not verify the slope of the velocity-distance relation.

Astronomical History

Colin A. Ronan's **Changing Views of the Universe** (Macmillan, New York, 1961. 206 pp. $3.95) is for the serious amateur and student; it is designed to provide a historical background against which the contemporary picture of astronomical research may be compared. Prehistory, early civilizations, Greek ideas, and the growth of astronomy in Western Christendom are well explained and make for good reading, although the book as a whole suffers from a dearth of explanatory drawings and pictures. The stature of Hipparchus, probably the greatest observational astronomer of antiquity, is clearly shown. A good modern biography of this great man would be most welcome. The stagnation of astronomy after the work of Ptolemy is a peculiar affair. A final death blow to Greek astronomical ideas and accomplishments occurred in A.D. 640 when the Mohammedan fanatic, Caliph Omar, ordered the destruction of the Alexandrian library. One might well ask, is it possible for such a thing to happen again?

The importance of the impact of technological developments such as the telescope is well emphasized: for example, "Photography brought the truly achromatic reflector back into favour, and it would be no exaggeration to say that the advent of spectroscopy and photography virtually changed the face of observational astronomy, as well as certainly having a profound effect upon cosmological speculation." It has often been said that technology depends on basic science; the reverse can also be true. Astronomers now study distant stars and galaxies in a variety of new ways because of highly developed and complex vacuum tubes, or multiplier phototubes, or, in the future, rockets.

The last chapter—"The twentieth century"—is unfortunately a real disappointment and mars an otherwise excellent book. A volume entitled *Changing Views of the Universe* should end with an adequate picture of what we *now* know about the universe and of how we learned these things. The great 20th century developments are given in the last 30 pages in vague or scrambled form or not at all. Shapley's great "leap of faith" which drastically changed our viewpoint from heliocentric to galactocentric is not described. The measurement of cosmological distances is not given nor is the greatest observed velocity of recession (now up to 46 percent of the velocity of light). Although there are a considerable number of pages on relativity and English cosmological speculations, there is but one sentence on the Lemaitre-Gamow "Big Bang" hypothesis and little or nothing on current ideas of stellar evolution. The exciting probable future history of the sun for the next 6 billion years is not given; an excellent account of this can be found in Stokley's book. The accomplishments and implications of radio astronomy are poorly presented. Half a sentence is devoted to 21-centimeter (hydrogen) radiation and nothing at all to colliding galaxies or radio signals from Jupiter or to radar contact with the Moon, Sun, and Venus. The definitions in appendix 5 for right ascension, celestial longitude, and stellar parallax are incorrectly given.

Galaxies Again

Harlow Shapley's contributions to astronomy over the past half century are numerous and fundamental. His discovery of the size of our galaxy and of the position of its distant center was one of the truly great accomplishments of this century. Shapley is also a successful popular writer, and his revised edition of **Galaxies** (Harvard University Press, Cambridge, Mass., 1961. 186 pp. $5), one of the Harvard Books on Astronomy, should sell well. In the 18 years since publication of the first edition large new optical telescopes at Lick, Palomar, Pretoria, Canberra, and Harvard Kopje have made notable contributions in this field; some of these are presented in this edition, but a great deal of current progress is omitted. As the author states in the preface, the contributions from radio telescopes, the motions of spiral arms, the new color-luminosity arrays for globular clusters, red-shift details, and new views on the ages and evolution of stars and galaxies are treated briefly or not at all. The new edition includes a number of the recent best photographs taken at Palomar or with the ADH Schmidt in South Africa. The discussion is essentially nonmathematical because, although it has often been found necessary to investigate the solar system with a ten-place electronic calculator, a 10-inch slide rule still suffices for most caiculations in the realm of the galaxies.

Summary

Shapley's book is the only one of the seven which will be of substantial assistance in the training of astronomy students at the graduate level. Although a number of excellent advanced monographs are now available or are in the making, textbooks on the junior, senior, and first-year graduate level are sorely needed.

The other volumes will be useful, in one way or another, to students and in informing the general public about astronomy. Both Schneider's and King's volumes will be helpful at the junior-high and high-school levels, and they will also be of interest to the general public. The volumes by Stokley and Inglis will probably find their greatest use at the beginning college level. *Music of the Spheres* is thoroughly enjoyable reading and should become a popular classic. Ronan's book, except for the shortcomings of the final chapter, gives a readable and well-balanced account of astronomical history.

Avian Functional Biology

Biology and Comparative Physiology of Birds. vol. 2. A. J. Marshall, Ed. Academic Press, New York, 1961. x + 468 pp. Illus. $14.

This volume contains 14 chapters, which, together with the 12 chapters of the first volume, offer the reader a comprehensive, carefully selected, and well-presented account of the functional biology of birds. As in the first volume, each chapter deals with a discrete subject and has a useful bibliography which readily enables non-

specialists to pursue further any topic of interest. The chapters deal with the central nervous system, with the sense organs having to do with taste, smell, equilibration, vision, and hearing, with the complex actions and interactions of the endocrine glands and their effect on other bodily functions, with the various problems of sex, secondary sexual characters, and of reproduction, and with those of energy metabolism, thermoregulation, and body temperature. The other topics covered are less often included in physiological treatises, but they clearly have physiological "roots"; these are flight, breeding seasons, migration, long-distance orientation, the nature and analysis of behavior, and demographic aspects of bird populations—such as longevity, sex ratio, territorial behavior, and the natural regulation of population numbers.

The contributing authors are R. H. J. Brown, D. S. Farner, J. A. Gibb, R. A. Hinde, E. O. Höhn, J. R. King, the late G. Kramer, A. J. Marshall, A. Portmann, R. J. Pumphrey, W. Stingelin, and E. Witschi. To them and to those who gave of their time and energy to the first volume of this highly useful compendium are due the continuing gratitude of all who have occasion to use the volumes.

HERBERT FRIEDMANN
Los Angeles County Museum, Los Angeles, California

Modern Physics for Laymen

The Atom and Its Nucleus. George Gamow. Prentice-Hall, New York, 1961, 153 pp. $1.95.

Atomic Physics Today. Otto R. Frisch. Basic Books, New York, 1961. vii + 254 pp. Illus. $4.50.

The Atom and Its Nucleus is both brief and densely packed with ideas. It is carefully organized with a definite continuity that begins with the early chemical evidence for the existence of atoms. The next four chapters present the experiments and the theoretical ideas which led up to the modern view of atomic structure. The development is well handled, within the limitations of extreme brevity.

The two chapters on radioactivity seem less impressive, perhaps because so many others have dealt with this topic on the popular level. The later chapters come alive when the author discusses the atomic nucleus, nuclear reactions, and the great variety of newly discovered elementary particles.

The careful reader who remembers some elementary algebra and elementary physics will find this book a rewarding summary of the highlights of atomic physics. There is very little mathematics, but this minimum is quite essential to the presentation. One can hardly criticize the author for the inevitable defects of a condensed treatment, but one can criticize the publisher for what seems to be hurried production with errors that will trouble the reader. The illustrations, in particular, show signs of undue haste; for example: I think the reader will wonder how the Davisson Germer experiment could produce a circular diffraction pattern. In one or two other cases the caption and the figure do not agree with each other, nor with the text.

Atomic Physics Today is a collection of articles and lectures and is therefore less rigidly organized. It is almost entirely qualitative and requires a minimum of technical background. Several chapters of this book, also, are devoted to developing the modern picture of atomic structure. In addition, Frisch covers such topics as the economics of nuclear power, the biological effects of radiation, and the use of radioisotopes in medical research and treatment. It should therefore appeal to a much wider audience than *The Atom and Its Nucleus*.

Perhaps the most worthwhile part of *Atomic Physics Today* is the section which describes the "hardware" of modern physics. Here the author does a remarkable job of explaining and putting in proper perspective various devices such as the bubble chamber, nuclear emulsions, scintillation counters, and other instruments essential to particle physics. He gives an excellent summary of the techniques of experimental physics, giving proper credit to the vital instruments which enable us to "see" elementary particles, but which are not so glamorous as the well-publicized accelerators.

The chapters on nuclear models and elementary particles are good, but perhaps suffer from being entirely nonmathematical and from making minimum use of illustrations. The concluding chapters present an interesting speculation about the notion of causality in relation to quantum theory and a well-argued justification for basic research. In spite of the limitations of a wholly verbal approach this may be an excellent first book for the adult with no previous exposure to physics.

In summary, both books endeavor to present modern physics to the nonphysicist; they differ in style and content, and each will appeal to a different group of readers.

MALCOLM K. SMITH
Science Teaching Center, Massachusetts Institute of Technology

Administration in Education

Governance of Colleges and Universities. John J. Corson. McGraw-Hill, New York, 1960. vii + 209 pp. $5.50.

The author of this book, the director for an international management consultant firm, who himself has had broad experience not only in business management but also in higher education as a professor and as a trustee, has investigated the obligations and responsibilities of college and university regents, administrators, and faculties. From a survey of institutions of higher education representative of private, public, and denominational colleges and universities with enrollments varying from 800 to 27,000 students, he has sought to determine how such schools are governed and how their governance might be improved.

The study was made to elucidate the general theory behind decision making in such institutions and to determine at what level decisions are made and how they are carried out. Unprecedented demands are about to be made upon colleges and universities because of the imminent increase in the numbers of students, the necessity of adapting higher education to the needs of modern society, and the need to continue to stimulate creativity.

Governance in colleges and universities differs from that of businesses and industries in that it serves a multiplicity of purposes. It must therefore be more dispersed than that of a typical business. The problems of decision making are carefully analyzed from the viewpoint of the board of trustees, the president, the deans, the department chairman, and the faculties. Among the problems are whether the final authority in matters of education policy should be delegated to the faculty, to what extent the faculty should act as advisors to the president and deans, and whether the president should hold himself apart

as a chief executive to whom recommendations go for approval or should serve largely as chairman of the faculty.

Additional discussion is concerned with the degree of communication that should be maintained between the faculty and the trustees and with how it should be maintained; with what organizational arrangements of faculties—such as senates, councils, and committees—can best assemble faculty opinion for the president and trustees; and with how faculties can be trained or persuaded to consider broad aspects of policy rather than the interests of individual disciplines.

Like other enterprises, the administration of a college involves the making of decisions, which are then implemented, communicated to those who must carry them out, and appraised in the light of results and of changing conditions. Unlike the administration of business and industry, good educational administration must focus on the development of the individual and must have the capacity for adaptability rather than the ability to maintain a smooth-running machine: a "tight ship." The goals of a university are not likely to be as clearly defined as those of an industry. They give greater opportunity for individual decisions by faculty members, but concomitantly place larger demands for leadership on presidents and trustees. Furthermore, the product or service provided by the university is less tangible than that of a business or industry. The commitments of the faculty are more likely to be to professions or disciplines than to the university or college itself. Moreover, faculty members expect the privileges of self-direction in their work and of participation in major decisions. As a result, the right to participate in decisions is far more diffused in universities than in almost any other enterprise.

One chapter gives special attention to the influence of outside agencies on the governance of universities: agencies such as contractual research organizations; federal, state, and local governments; accreditation agencies; and donors.

The final chapter is given over to a searching analysis of institutional character. This chapter will be of exceptional interest not only to those who govern universities but to all who are connected in any way with college and university communities.

LAURENCE H. SNYDER
University of Hawaii

Yesterday in Tanganyika

The Lake Regions of Central Africa. A picture of exploration. Sir Richard F. Burton. Introduction by Alan Moorehead. Horizon Press, New York, 1961. vol. 1, xxiv + 421 pp.; vol. 2, viii + 468 pp. Illus. $15, the set.

The Lake Regions of Central Africa first appeared in 1861. In 1857, Burton had set out with his companion John Speke to reach and explore Lake Tanganyika. When they returned in 1859, they were the first European travelers to have followed the caravan route from the coast to the lake, and they had also made the first circumnavigation of Tanganyika. The route they traveled was already well known to Arab and Indian merchants. Indeed, the expedition would have ended in failure at a number of points had it not been for the hospitality and assistance offered by Arab traders who had established posts far inland. This in no way diminishes what Burton and Speke accomplished, for they were the first to seek to describe the country and to share their knowledge with the world. In the hundred years since Burton's account first appeared, it has become one of the classics of African exploration, notable not only for its description of an Africa of yesterday, set forth in magnificent prose, but also for the light it throws on one of the most remarkable men of the 19th century. Long out of print, it has become a rare book. Now Horizon Press has republished it in a beautiful two-volume edition carrying the original illustrations.

In a hundred years, Tanganyika has changed dramatically, yet Burton's book remains of enduring interest. There is no question of its importance as a historical document. In many instances it is the earliest report on various peoples of the interior. Burton had the seeing eye, the questioning mind, the interest in manners and customs that made him the ideal observer. He could also be opinionated and prejudiced, and sometimes he was just plain wrong, but at this distance, this seems to matter little. His eye for country was even better than his eye for custom. He gives the results of his geographical observations and then tops this with a word picture of the landscape. He describes African villages and Arab trading camps, discusses the terms of trade, examines the organization of the various types of caravans, and passes free comment upon all whom he encounters. He leaves little to the imagination with regard to the physical hardships and great discomforts to be encountered over almost every leg of the journey.

The reappearance of *The Lake Regions of Central Africa* will be welcomed by anthropologists, historians, and geographers interested in Africa, and no less by all those who enjoy books of exploration.

E. COLSON
Department of Anthropology, Brandeis University

Soviet Oceanography

Okeanologiya. L. A. Zenkevich, Ed. Oceanographic Commission, Soviet Academy of Sciences, Moscow, 1961. 190 pp. Illus. $12.50 per year (six issues per year).

The first issue of a new journal, *Okeanologiya* (*Oceanology*), has just been released by the Oceanographic Commission of the Soviet Academy of Sciences. The journal, which will bring together papers from Russian oceanographic research, should be translated into English as an aid for Western readers who wish to keep abreast of the rapid advances in Soviet oceanography.

Volume 1, Number 1, the first of six issues to be released during 1961 under the general editorship of L. A. Zenkevich, contains 190 pages and includes 16 papers dealing with physical, chemical, biological, and geological oceanography; 2 articles on apparatus and methods; 3 book reviews; and 12 news items. An English table of contents is supplied, but unfortunately no abstracts, either in English or in Russian, are provided.

Twelve basic problems, which are to be reflected in papers published in the journal, are outlined in a nine-page editorial. These problems are: structure of waters of the world ocean and physical processes taking place in it; chemical structure of water masses of the ocean and chemical processes occurring therein; interaction of the ocean and atmosphere; biological structure of the ocean and its organic resources; geologic structure of the ocean floor; structure of the earth's crust under the ocean; interaction of the

ocean and lithosphere; history of the world ocean; mineral resources of the ocean; energy resources of the oceans; complex regional natural resources of seas and oceans; preservation of resources and change in the character of the world ocean.

Subscriptions may be placed with any of the official dealers in Soviet publications in the United States or abroad.

JOHN W. WINCHESTER
Department of Geology and Geophysics, Massachusetts Institute of Technology

Criteria for Publication

Apples of Immortality from the Cuna Tree of Life. The study of a most ancient ceremonial and a belief that survived 10,000 years. Clyde E. Keeler. Exposition Press, New York, 1961. 72 pp. Illus. + plates. $3.50.

The subtitle of this book, "The study of a most ancient ceremonial and a belief that survived 10,000 years," immediately arouses in any anthropologist the suspicion that here is another amateur, speculative endeavor addressed to large issues in cultural history. Reading the volume confirms the suspicion.

Clyde Keeler is a geneticist, with more than creditable recognition in his own field, who has adopted the San Blas Cuna Indians of eastern Panama as a hobby-like subject of study; over the years, he has developed a familiarity with some of the people and an undisciplined knowledge of the formal ethnographic literature concerning them. The present book purports to trace certain Cuna rites and usages concerned with the fruits of the *Genipa americana* tree (employed on certain occasions as a body "paint" or dye) to the Tree of Life motif in the mythologies of the Near East and elsewhere. In the course of the book, the reader is confronted with figures and text references pertaining to Egypt, India, Sumeria, the Upper Paleolithic of Western Europe, Mexico, Arizona, British Columbia, and points between.

An appeal is made to the long-since discredited Heliolithic theory of cultural history of Sir Grafton Elliot Smith, to the possibility that Phoenician trading colonies were the origin of both the Mandan and Hopi Indian tribes of North America, and to the "expert" knowledge of a Potawatomi Indian to whom Keeler sent some of his findings for evaluation. His general conclusion is that present Cuna practices are a stage in the Tree of Life myths and ceremonies, and their depiction, held by diverse other peoples of between 6000 and 10,000 years ago.

The author states in his final paragraph "that to conjecture this is anthropological heresy today. . ."; with this I agree, stipulating, however, that the word "heresy" be replaced by "fantasy."

The merits of this book aside, it is one more reason for raising the question: "Why does an expert in one field think that his hobby, however satisfying to him, is sufficiently disciplined to merit publication and serious consideration by other scholars?" Surely, Keeler would not employ the low standards in the collection and assessment of evidence and in the selection of what fits the case and the rejection of what does not in his genetic research that he has applied in writing *Apples of Immortality*. . . .

DAVID B. STOUT
Department of Anthropology and Linguistics, University of Buffalo

New Books

Mathematics, Physical Sciences, and Engineering

Artificial Satellites. Michael W. Ovenden. Penguin Books, Baltimore, Md., 1961. 128 pp. Illus. $1.25.

College Physics. Ray W. Kenworthy. Davis, Philadelphia, Pa., 1961. 671 pp. Illus. $8.50.

Concepts from Tensor Analysis and Differential Geometry. Tracy Y. Thomas. Academic Press, New York, 1961. 126 pp. Illus. $5.

Descriptive Palaeoclimatology. A. E. M. Nairn, Ed. Interscience, New York, 1961. 391 pp. Illus. $11.

The Earth Today. A collection of papers dedicated to Sir Harold Jeffreys. A. H. Cook and T. F. Gaskell, Eds. Royal Astronomical Soc., London, 1961 (order from Oliver and Boyd, London). 414 pp. Illus. 80s.

Electrical Engineering. S. B. Hammond. McGraw-Hill, New York, 1961. 576 pp. Illus. $8.75.

Electrical Estimating. Ray Ashley. McGraw-Hill, New York, ed. 3, 1961. 446 pp. Illus. $12.50.

Engineering Data for Product Design. Douglas C. Greenwood, Ed. McGraw-Hill, New York, 1961. 438 pp. Illus. $10.

Full-Scale Fatigue Testing of Aircraft Structures. F. J. Plantema and J. Schijve, Eds. Pergamon, New York, 1961. 436 pp. Illus. $15. Proceedings of a symposium held in Amsterdam, Netherlands, June 1959.

Fundamental Mathematics. Thomas L. Wade and Howard E. Taylor. McGraw-Hill, New York, ed. 2, 1961. 442 pp. Illus.

Gas Chromatography. Ernst Bayer. Elsevier, Amsterdam, 1961 (order from Van Nostrand, Princeton, N. J.). 252 pp. Illus. $5.

Gas Sampling and Chemical Analysis in Combustion Processes. G. Tine'. Pergamon, New York, 1961. 109 pp. Illus. $6.

An Introduction to Relativistic Quantum Field Theory. Silvan S. Schweber. Row, Peterson, Evanston, Ill., 1961. 917 pp. Illus.

Introductory Systems Analysis. Signals and systems in electrical engineering. William A. Lynch and John G. Truxal. McGraw-Hill, New York, 1961. 473 pp. $7.50.

Iterative Arrays of Logical Circuits. Frederick C. Hennie, III. Massachusetts Inst. of Technology Press and Wiley, New York, 1961. 252 pp. Illus. $4.95.

Lectures in Theoretical Physics. Wesley E. Brittin, B. W. Downs, and Joanne Downs, Eds. Interscience, New York, 1961. 539 pp. Illus. $11.

Physical Chemistry. E. A. Moelwyn-Hughes. Pergamon, New York, ed. 2, 1961. 1340 pp. Illus. $17.50.

Physical Chemistry of Process Metallurgy. pts. 1 and 2. George R. St. Pierre, Ed. Interscience, New York, 1961. 658 pp.; 1402 pp. Illus. pt. 1, $22.50; pt. 2, $25. Proceedings of an international symposium sponsored by the Metallurgical Society.

Quantum Mechanics. Eugen Merzbacher. Wiley, New York, 1961. 556 pp. Illus.

Radiation Chemistry of Gases. Samuel C. Lind. Reinhold, New York; Chapman and Hall, London, 1961. 323 pp. Illus. $12.50.

Reference Electrodes. Theory and practice. David J. G. Ives and George J. Janz, Eds. Academic Press, New York, 1961. 662 pp. Illus. $20.

Special Ceramics. P. Popper, Ed. Academic Press, New York, 1960. 381 pp. Illus. $10.50. Proceedings of a symposium held by the British Ceramic Research Association, July 1959.

Soviet Research in Catalysis, 1956. pt. 1. *Theoretical and Sundry Associated Effects*, 46 pp., $15; pts. 2a and 2b, General, pp. 47–569, $60; pt. 3. *Reduction, Oxidation, Fischer-Tropsch*, pp. 571–647, $15; pt. 4, *Hydrogenation; Cracking*, pp. 649–805, $15. Consultants Bureau, New York, 1959. Selected reports reprinted from 1956 issues of journals translated by the publisher.

Tables of Airy Functions and Special Confluent Hypergeometric Functions. For asymptotic solutions of differential equations of the second order. A. D. Smirnov. Translated from the Russian by D. G. Fry. Pergamon, New York, 1960. 267 pp. Illus. $15.

Tables of Elementary Functions. Mieczyslaw Warmus. Pergamon, New York; Państowowe Wydawnictowo Naukowe, Warsaw, Poland, 1960. 574 pp. $15.

Theory of Hydrodynamic Lubrication. Oscar Pinkus and Beno Sternlicht. McGraw-Hill, New York, 1961. 479 pp. Illus. $15.

Reports

Anopheles hackeri, a Vector of Plasmodium knowlesi in Malaya

Abstract. *Anopheles hackeri*, a mosquito commonly found breeding in nipa palm leaf bases along the Malayan coast, was demonstrated to be infected with *Plasmodium knowlesi* by the inoculation of sporozoites into an uninfected rhesus monkey. This was the first demonstration of a natural vector of any monkey malaria.

The discovery that a Malayan strain of *Plasmodium cynomolgi bastianellii*, isolated from the long-tailed macaque, *Macaca irus*, was transmissible to man (*1*) has stimulated inquiries into the vectors of monkey malaria in nature. Although the identity of the main human vectors in Malaya, *Anopheles maculatus*, *A. letifer*, *A. umbrosus*, *A. sundaicus*, and the dark-winged form of *A. barbirostris*, is well established (*2*), virtually nothing is known about transmission of monkey malaria.

There has been some doubt about the origin of oöcyst and sporozoite infections in certain anophelines, and in particular, J. A. Reid of the Institute for Medical Research of the Federation of Malaya suspected that two members of the *A. leucosphyrus* group, *A. hackeri* and *A. pujutensis*, were vectors of monkey malaria. An investigation of their feeding habits showed that neither was attracted to man, but both were caught on monkey bait, and precipitin tests of blood from adults caught by day confirmed that these mosquitoes fed on monkeys in nature (*3*). Efforts have been made to identify the infections in these mosquitoes, and a strain of *Plasmodium knowlesi* has been isolated in a rhesus monkey inoculated with sporozoites from *Anopheles hackeri*.

Until comparatively recently *A. hackeri* was regarded as a rather rare mosquito breeding in split bamboos in inland forest, but, as described by Reid and Weitz (*3*), it is now known to be quite common on the Selangor coast, where the larvae and adults were found in the old leaf bases of the nipa palm (*Nipa fruticans*).

Our studies were made in the vicinity of Kampong Rantau Panjang, north of Klang near the Selangor coast, and this was also the area studied by Reid and Weitz (*3*). In the study area, which bordered on mangrove swamp, nipa palms were extensively cultivated. *Anopheles hackeri* larvae were found in the old leaf bases of the palms, and resting adults could be collected a few inches above the water line at the rate of about five females per man-hour by experienced collectors. During the study period *A. pujutensis* was not found frequently.

Through trapping mosquitoes the conclusion of Reid and Weitz (*3*) that *A. hackeri* is attracted to monkeys was verified. Over a period of 34 nights, 20 *A. hackeri*, including 17 which were blood-fed, were taken in a monkey-baited open net trap on a platform in the canopy 20 ft above ground level. Four mosquitoes were taken in a similar trap on the ground, but none of the four was blood-fed. Nearly all of the mosquitoes were caught on two nights, eight on one night and seven on the other, and each time the majority were caught about 1 hr after sunset. The irregularity in trapping the mosquitoes was puzzling in view of their consistent presence as resting adults in nipa leaf bases and possibly indicated that they are shy feeders. Other trapping methods were unsuccessful.

A man-baited net trap at ground level caught 13 *A. hackeri*. This was surprising, as none had been caught in more extensive efforts by Hodgkin (*2*) or Reid and Weitz (*3*). For our observations the traps were situated close to the breeding grounds, and the catching of *A. hackeri* in the man-baited trap is probably of little significance, since, as Colless (*4*) has shown, mosquitoes flying at random easily enter such traps even when they are unbaited.

Precipitin tests made with blood from freshly fed mosquitoes captured from nipa leaf bases confirmed the finding of Reid and Weitz (*3*) that *A. hackeri* was feeding upon monkeys.

Many mosquitoes from the nipa leaf bases and from the traps were dissected, and only one sporozoite infection was found in over 700 mosquitoes dissected. This is a much lower rate than the 4 percent recorded by Reid and Weitz (*3*). Mosquitoes were dissected in monkey serum-saline (one part serum to four parts physiological saline), and the sporozoites were inoculated intravenously into an uninfected Indian rhesus monkey (*Macaca mulatta*).

Small ring forms were seen in small numbers in the blood 6 days later, and the infection built up with such rapidity that the monkey died in another 3 days. The periodicity was quotidian, and the parasites were morphologically identified as *Plasmodium knowlesi*.

The infection was transferred to a second monkey, and infected blood was shipped to the United States for further study. This strain has been designated the *hackeri* strain of *Plasmodium knowlesi*.

The demonstration that *Anopheles hackeri* is a natural vector of one of the species of monkey malaria is the first such demonstration on record, but it falls far short of explaining the widespread occurrence of monkey malaria. Monkey malarias occur in many areas in which this species of mosquito does not occur commonly. It is possible that other members of the *Anopheles leucosphyrus* complex are involved.

Our laboratories have initiated an extensive investigation of the epidemiology of monkey malarias, of which this study is a part. The transmission of monkey malarias as related to

---

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* **125**, 16 (1957)].

human malarias is being studied in a number of ecologically diverse situations in Malaya, to determine whether malaria is, under any circumstances, a zoonotic disease in nature.

R. H. WHARTON
Institute for Medical Research, Kuala Lumpur, Federation of Malaya
DON E. EYLES
Laboratory of Parasite Chemotherapy, National Institute of Allergy and Infectious Diseases, Chamblee, Georgia

References

1. D. E. Eyles, G. R. Coatney, M. E. Getz, *Science* **131**, 1812 (1960).
2. E. P. Hodgkin, *Studies Inst. Med. Research, Federation Malaya* **27**, 1 (1956).
3. J. A. Reid and B. Weitz, *Ann. Trop. Med. Parasitol.*, in press.
4. D. H. Colless, *ibid.* **53**, 251 (1959).

17 April 1961

Suppression of Shoot Formation in Cultured Tobacco Cells by Gibberellic Acid

Abstract. When tobacco pith was cultured on media containing gibberellic acid, shoot formation was observed. The formation of stem structures was strikingly suppressed by concentrations of 0.5 mg/lit. and above.

Application of gibberellins has generally resulted in promotion, rather than suppression, of plant growth processes. One of the few instances of suppression reported is in the rooting of cuttings. Gibberellin treatments not only inhibited rooting of cuttings, but also counteracted the stimulation caused by auxin (*1*). In tests performed with cultured tobacco cells, I found that gibberellic acid indeed prevented formation of roots under otherwise favorable conditions.

The present report considers the effect of gibberellin on the formation of stem structures in cultured cells. A preliminary study showed complete suppression of shoot formation when 5 mg of gibberellic acid per liter was included in the culture medium. Representative cultures can be seen in Fig. 1. The present experiment extends this observation to other concentrations of the growth regulator.

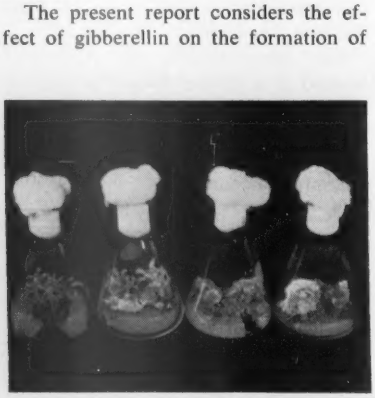


Fig. 1. Formation of shoots in cultured tobacco cells as influenced by gibberellic acid. Pair on left, no gibberellin; pair on right, 5 mg of gibberellic acid per liter.

Tobacco (*Nicotiana tabacum* L. var. Wisconsin 38) pith, which had been in continuous culture for the last several years at the University of Wisconsin, was employed (*2*). The basal medium of Miller *et al.* (*3*), supplemented with three times the level of inorganic phosphate, 0.5 mg of 3-indoleacetic acid, 2 mg of kinetin (*2*), and 150 mg of L-tyrosine per liter, was utilized. The reports of others (*4, 5*) and my experience showed that these levels of the supplements were optimum for shoot formation in cultured tobacco cells. Gibberellic acid (*6*) was included (0, 0.5, 1.0, 5.0 and 10.0 mg/lit.). Solutions of this compound were sterilized by Millipore filtration to avoid any undesirable consequence of heating.

For each level of gibberellin, ten 25- by 150-mm culture tubes, each containing 25 ml of medium, were employed. One piece of callus, roughly 2 mm^3 and weighing about 40 mg, was cultured in each tube. The cultures were maintained at 21° to 27°C under continuous weak light from overhead fluorescent fixtures.

The numbers of cultures with shoot and shoots per culture recorded after 7 wk are shown in Table 1. Controls on basal medium showed profuse shoot development, whereas cultures supplied with gibberellic acid in any concentration exhibited marked suppression. Levels of 5 and 10 mg/lit. of the compound were completely antagonistic. This suppression of shoot formation is most probably not due to toxicity, since no reduction in callus growth was observed in any of the treatments. Furthermore, the concentrations presently employed ranged below that found by Nickell and Tulecke (*7*) to be promotive in growth tests with cell cultures of a large number of species.

These findings, together with earlier reports of inhibition of rooting, show that gibberellin is indeed physiologically distinct from either auxin or kinin. Auxin tends to promote rooting, and kinin enhances shoot formation (*5*). If the amounts of gibberellin presently incorporated into the culture medium can be assumed to have resulted in levels which do not exceed the normal physiological range in the cells, then the data reveal that, whereas gibberellin is known to stimulate organ enlargement, the stem in particular, it antagonizes the initiation of the structure (*8*).

Table 1. Shoot formation in cultured tobacco pith as influenced by gibberellic acid.

Gibberellic acid in medium (mg/lit.)	Cultures with shoot (No.)	Shoots per culture (No.)
0	10	29 ± 4
0.5	3	0.6 ± .4
1.0	4	1.3 ± .6
5.0	0	0
10.0	0	0

TOSHIO MURASHIGE
Hawaii Agricultural Experiment Station, Honolulu

References and Notes

1. P. W. Brian, H. G. Hemming, M. Radley, *Physiol. Plantarum* **8**, 899 (1955); R. A. Gray, *Plant Physiol.* **33**, 40 (1958); J. Kato, *Physiol. Plantarum* **11**, 10 (1958).
2. Both tobacco pith and kinetin were obtained through the courtesy of Folke Skoog, University of Wisconsin.
3. C. O. Miller, F. Skoog, F. S. Okumura, M. H. von Saltza, F. M. Strong, *J. Am. Chem. Soc.* **78**, 1375 (1956).
4. C. E. LaMotte and F. Skoog, *Plant Physiol.* **35**, 19 (1960).
5. F. Skoog and C. O. Miller, *Symposia Soc. Exptl. Biol. No. 11*, 118 (1957).
6. A purified sample containing 90-percent gibberellic acid was kindly furnished by Eli Lilly & Co., Indianapolis, Ind.
7. L. G. Nickell and W. Tulecke, *Botan. Gaz.* **120**, 245 (1959).
8. This report is published with the approval of the director, as technical paper No. 521 of the Hawaii Agricultural Experiment Station.

28 February 1961

Acid-Catalyzed Oxidation of Reduced Pyridine Nucleotides

Abstract. Reduced pyridine nucleotides are oxidatively catalyzed in weakly acidic solutions. The rate is proportional to the acidity, and at constant acidic *p*H, the reaction follows first-order kinetics. The rate of oxidation of reduced triphosphopyridine nucleotide is approximately 3 times that of reduced diphosphopyridine nucleotide. The reaction offers a very plausible explanation for the metabolic efficiency of the malignant tumor cell. It may also play a key role in wound healing and muscle contraction.

When reduced pyridine nucleotides (DPNH and TPNH) (*1*) are dissolved in weakly acidic buffers, they are found to undergo catalytic oxidation which may be followed spectrophotometrically by the decrease in optical density at 340 mμ. If the concentration is expressed in terms of optical density, the reaction follows first-order

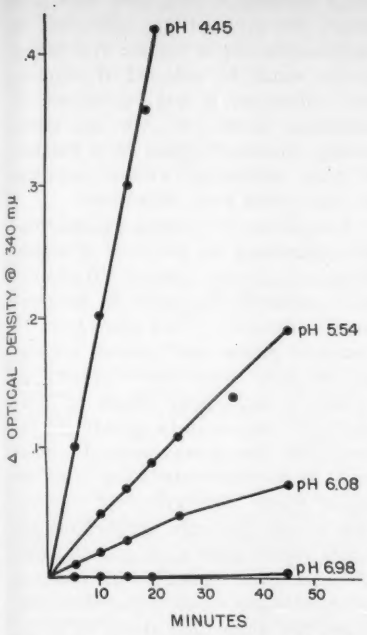


Fig. 1. Acid-catalyzed oxidation of DPNH.

kinetics at a given acidic *p*H. The *p*H dependency of the reaction rate is indicated in Fig. 1 for DPNH in phosphate buffers. The decrease in optical density is recorded as positive integers.

When the oxidative rates are compared for equivalent concentrations of DPNH and TPNH at constant acidic *p*H, the rate for TPNH oxidation is approximately 3 times that for DPNH oxidation. This is shown in Fig. 2.

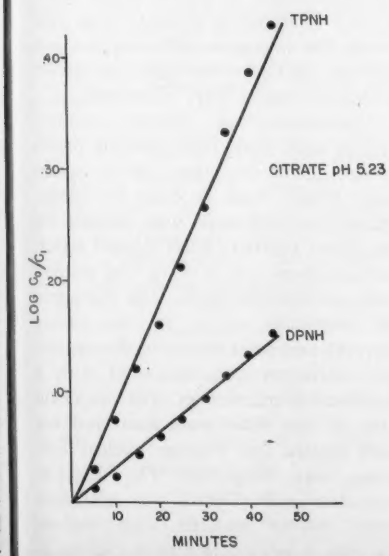


Fig. 2. Acid-catalyzed oxidation of TPNH and DPNH.

Preliminary experiments suggest that the reaction does not involve heavy metal catalysis, for no inhibition is observed with 1×10^{-2} m*M* NaCN; nor is there any curtailment of activity noted in a metal-free buffer prepared from "tris" (tris-hydroxymethylaminomethane) and HCl. However, this aspect is being investigated more fully, since oxidative catalysis without heavy metal participation is indeed a singular event. Evidence thus far points to the pyridine moiety as being the sole locus of oxidation. The purine component remains unaltered, as evidenced by measurements at 260 mμ.

The biochemical importance of the reaction becomes apparent when it is recalled that TPNH exists in considerable excess over triphosphopyridine nucleotide in all tissues (*2*). The interpretation generally given is that the oxidation of TPNH is a rate-determining step in the various biosynthetic reactions in which it is linked (*3*). This is probably true for normal cells, which function in the *p*H range of 7.0 to 7.4. However, for malignant tumor cells, which metabolize in decidedly acidic *p*H (*4*), primarily because of accumulated lactic acid (*5*), the oxidation of TPNH would not be rate-limiting. This reaction therefore represents a means by which a tumor cell exercises metabolic superiority over the normal cell. It also explains the so-called "nitrogen trap" mechanism usually associated with tumors, for the accelerated TPNH oxidation would result in the sparking of biosynthetic reactions.

The reaction may also play a key role in wound healing and muscle contraction, processes in which there is a local sharp drop in *p*H (*6*). In wound healing, the injured tissue, aided by the nonenzymic oxidative catalysis, would emphasize the synthetic reactions of repair until the *p*H returns to neutrality. Lactic acid formed in muscle contraction would stimulate the TPNH-linked synthesis of glycogen. The difference between the malignant tumor and these two processes is that there is no return to neutrality in the case of the tumor (*7*).

I. Gordon Fels

Radioisotope Research Section,
Veterans Administration Hospital,
Hines, Illinois

References and Notes

1. DPNH (Sigma), enzymatically reduced diphosphopyridine nucleotide, 90 percent pure; TPNH (Sigma), enzymatically reduced triphosphopyridine nucleodtide, 96.5 percent pure.
2. G. E. Block and P. McLean, *Biochem. J.* **61**, 388 (1955).
3. N. O. Kaplan, M. N. Swartz, M. E. Frech, M. M. Ciotti, *Proc. Natl. Acad. Sci. U.S.* **42**, 481 (1956).
4. H. Kahler and W. Van B. Robertson, *J. Natl. Cancer Inst.* **3**, 495 (1943); C. Voegtlin, R. H. Fitch, H. Kahler, J. M. Johnson, J. W. Thompson, *Public Health Bull. No. 164* (1935), p. 15.
5. C. F. Cori and G. T. Cori, *J. Biol. Chem.* **64**, 11 (1925); **65**, 397 (1925).
6. L. B. Arey, *Physiol. Revs.* **16**, 327 (1936).
7. I acknowledge with gratitude the assistance of Marian Berman in preparing the figures.

5 April 1961

L-Tyrosine Oxidase System in Tuber of Nutsedge

Abstract. In the nutsedge, *Cyperus rotundus* L., the oxidation of L-tyrosine follows steps similar to those reported for mammalian liver and *Blattella conjuncta*. The system is activated by α-ketoglutarate, L-ascorbic acid, glutathione, and pyridoxal phosphate. Folic acid markedly inhibits the reaction.

Previous studies (*1*) have shown that the nutsedge tuber has an active tyrosinase. Ascorbic acid activated 3,4-dihydroxyphenylalanine (DOPA) oxidase, but ascorbate inhibited the complete oxidation of this compound to hallochrome. The dormant tuber contains large quantities of ascorbic acid (115 mg/100 g of fresh weight), and it is evident that this vitamin undoubtedly plays a vital role in the metabolism of the tuber. The function of ascorbic acid in the L-tyrosine oxidase system has been shown for mammalian liver (*2, 3*) and *Blattella conjuncta* (*4*).

The purpose of the present study was to follow the oxidation of L-tyrosine by nutsedge tuber tissue as influenced by α-ketoglutarate and certain cofactors.

Dormant nutsedge tubers were taken from greenhouse pots. The tubers were homogenized at 2°C in a chamber of the Omni mixer which contained 100 ml of 0.2*M* potassium phosphate buffer at *p*H 6.8. The suspension was strained through one layer of cheesecloth, and the filtrate was centrifuged at 1300*g* for 10 min at 2°C.

Activity was determined by conventional Warburg methods at 25°C. The vessels contained the cofactors and substrates in a total volume of 2.4 ml of 0.2*M* potassium phosphate buffer. A 0.6-ml portion of the homogenate was placed in the side arm. The reaction was initiated by tipping the side arm. The final *p*H for the treatments was

Table 1. Effects of α-ketoglutarate and other components on the tyrosine oxidase activity of a homogenate of nutsedge tubers.

Components added to homogenate	Activity $Q_{O_2}^{O_2}$ (N)
None	17
α-ketoglutarate (α-K)	26
α-K + folic acid	3
α-K + ascorbate	31
α-K + pyridoxal phosphate	36
α-K + glutathione	56
α-K + glutathione + ascorbate	37
α-K + glutathione + ascorbate + pyridoxal phosphate	68
None + glutathione + ascorbate + pyridoxal phosphate	31
α-K + glutathione + ascorbate + pyridoxal phosphate + folic acid	18
None + glutathione + ascorbate + pyridoxal phosphate + folic acid	30

7.0. Activity measurements were taken for 1 hr.

The final concentrations of L-tyrosine and α-ketoglutarate were $6.8 \times 10^{-3}M$ and $5 \times 10^{-2}M$, respectively, while the final concentration of the cofactors was: ascorbic acid, $5 \times 10^{-2}M$; pyridoxal phosphate, $5 \times 10^{-5}M$; reduced glutathione, $3.3 \times 10^{-3}M$; folic acid, $5 \times 10^{-4}M$.

Table 1 shows results of a typical experiment. Activity was stimulated by α-ketoglutarate alone, or in combination with either ascorbic acid, pyridoxal phosphate, or glutathione, but the greatest effects were obtained with a single combination of these. Folic acid with only α-ketoglutarate or in combination with the afore-mentioned cofactors markedly inhibited activity. These results are contrary to the stimulation by folic acid reported for this system in mammalian tissue (*3*) and the cockroach (*4*). Preliminary studies (*5*) indicate that folic acid is required for the oxidation of L-phenylalanine to L-tyrosine in the nutsedge homogenates.

It appears that the oxidation of L-tyrosine by homogenates of nutsedge follows a pathway in which tyrosine is deaminated by a transamination reaction with α-ketoglutarate, which requires pyridoxal phosphate (*6*) and yields *p*-hydroxyphenylpyruvic acid (Fig. 1). This acid is oxidized to homogentisic acid and carbon dioxide. This system in nutsedge evolved 115 $Q_{CO_2}^{O_2}$ (N) with the combination of cofactors in Table 1 that gave the greatest activity. The intermediate, 2,5-dihydroxyphenylpyruvic acid, is involved in the process which requires ascorbic acid and glutathione.

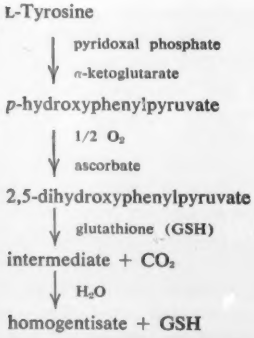


Fig. 1. A proposed scheme for the oxidation of L-tyrosine in *Cyperus rotundus* L.

The present study establishes that L-tyrosine is oxidized by a pathway similar to that reported in mammals and the cockroach (*7*).

RUPERT D. PALMER
Department of Plant Physiology and Pathology, Mississippi State University, State College

References and Notes

1. R. D. Palmer and W. K. Porter, Jr., *Weeds* **7**, 503 (1959).
2. J. N. Williams, Jr., and A. Sreenivasan, *J. Biol. Chem.* **203**, 605 (1953).
3. ———, *ibid.* **203**, 613 (1953).
4. M. H. Briggs, *Science* **132**, 92 (1960).
5. R. D. Palmer, unpublished data.
6. Z. N. Canellakis and P. P. Cohen, *J. Biol. Chem.* **222**, 53, 63 (1956).
7. This work was supported in part by cooperative Regional Research Project S-18. This report is a contribution from the Mississippi Agricultural Experiment Station, journal paper No. 892.

1 February 1961

Correlation of Nuclear Volume and DNA Content with Higher Plant Tolerance to Chronic Radiation

Abstract. The causes of extreme differences in radiosensitivities of different plant (or animal) species have long puzzled radiobiologists. Our investigations show that, for diploid species, the larger the nuclear volume, the more radiosensitive the organism. Correspondingly, species with large nuclei have more deoxyribonucleic acid (DNA) per nucleus than those possessing small nuclei. Our data now make it possible to predict fairly accurately the tolerance of plant species to ionizing radiation on the basis of average nuclear volume and DNA content. The same correlations are expected to hold for some microorganisms and for animals and may explain differences in sensitivities of different cell types in many living organisms.

It has been noted in previous investigations (*1–3*) that the chromosome size characteristic of a species is related to the amount of radiation required to produce a given effect. In view of the tedious nature of accurately determining chromosome size or volume, no really quantitative data have been presented. We assumed that differences in chromosome size or volume in different species would be reflected in comparable differences in size or volume of interphase nuclei (*4*). On this basis, average nuclear volumes of a number of plant species of known radiation tolerance have been determined.

A summary of preliminary information concerning the tolerance of higher plants to chronic gamma irradiation from cobalt-60 was given by Sparrow and Christensen (*2*). In a later report 79 species of plants were grouped according to daily dose rates required to produce a comparable degree of morphological deformity or growth inhibition. The dose rates required varied from 30 to 6000 r/day. The most resistant plants were polyploid (*3*). In most of our tolerance experiments accurate measurements of growth inhibition were not made, but the row (or group) of plants which appeared to have shown not more than about 10 to 20 percent of the normal growth was chosen as the critical dosage level. Thus, the end point used was an approximation which can be assumed to be the daily dose rate which would essentially stop further cell division. In our studies the critical dosage level as determined above seems sufficiently valid because the possible error for each species is relatively small compared to the variation between species. By using the degree of growth inhibition as a measure of radiation damage, we have found that plant species ranging from algae to higher plants differ in their tolerance by a factor of at least 5000. The tolerance difference was still at least 100-fold when algae and known polyploid species were eliminated.

Collections for nuclear volume studies were made from growing plants before floral transition. Shoot apices were killed, fixed in Craf III, dehydrated, and infiltrated with paraffin by the use of a tertiary butyl alcohol series. Sections were cut at 10 μ and stained with safranin-fast green. The diameters of interphase nuclei in the tunica layer(s) and outer corpus of the vegetative meristems were measured with a Zeiss ocular micrometer. Ten nuclei on each of two slides were measured for each species, and average nuclear volumes were calculated. The deoxyribonucleic acid (DNA) was extracted from root-tip material with sodium chloride, a modification of the Schmidt-Thannhauser procedure (*5*), and the amount of DNA was estimated by the

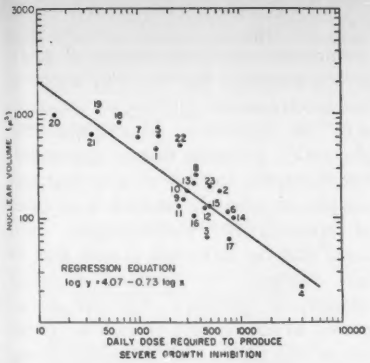


Fig. 1. Relationship between nuclear volume and radiosensitivity in 23 species of plants. 1, *Allium cepa.* 2, *Anethum graveolens.* 3, *Antirrhinum majus.* 4, *Arabidopsis thaliana.* 5, *Brodiaea bridgesii.* 6, *Graptopetalum bartramii.* 7, *Haworthia attenuata.* 8, *Helianthus annuus.* 9, *Impatiens sultanii.* 10, *Luzula purpurea.* 11, *Nicotiana glauca.* 12, *Oxalis stricta.* 13, *Pisum sativum.* 14, *Raphanus sativus.* 15, *Ricinus communis.* 16, *Saintpaulia ionantha.* 17, *Sedum oryzifolium.* 18, *Tradescantia ohiensis.* 19, *Tradescantia paludosa.* 20, *Trillium grandiflorum.* 21, *Tulbaghia violacea.* 22, *Vicia faba.* 23, *Zea mays.*

diphenylamine reaction (*6*). The nuclear volumes of the root and shoot meristem cell nuclei are approximately the same in the plants studied.

The average volumes of shoot meristem nuclei from 23 diploid species were plotted against the chronic daily dose required to produce severe inhibition of growth. The resultant graph (Fig. 1) shows a clear relationship between the two variables—that is, in general, the larger the nuclear volume the more sensitive the cells (or meristems) of that species. The population regression line has a negative slope of mean value −0.73 with 95-percent confidence limits of −0.882 to −0.582. While the slope of the curve relating nuclear volume and radiosensitivity is less than −1, this does not rule out the possibility that it may approach a slope of −1 when more extensive data are available. A slope of −1 would be of considerable interest since it would mean that the product of the two variables (log dose × log nuclear volume) would be a constant. Since dose can also be expressed as ionizations per unit volume, we can deduce that a reasonably constant number of ionizations is required to inhibit multiplication of somatic diploid cells regardless of the average size of the nucleus (*7*).

Table 1. DNA content and average volume of root-tip nuclei and radiosensitivity of six species of plants. The chromosome number of the species is shown in parentheses. Determinations: P, photometric; E, chemical extraction.

Av. vol. of root-tip nuclei (μ^3)	DNA content ($\mu\mu$g) per Nucleus P*	Nucleus E	Chromosome E	Radiosensitivance (r/day)†
	Lilium henryi (24)			
1100	100	100	4.1	80‡
	Tradescantia paludosa (12)			
640	52	59.4	5.0	40
	Allium cepa (16)			
570	40	54.3	3.4	150
	Vicia faba (12)			
490	18	38.4	3.2	120
	Zea mays (20)			
280	4	14.1	0.7	375§
	Glycine max (40)			
150		6.5	0.16	400

*As determined by Rasch and Woodard. †Daily dose required to produce severe growth inhibition (in gamma greenhouse). ‡Estimated value based on data for *Lilium longiflorum.* §Estimated value based on field experiment.

It has been reported that nuclear volume and the amount of DNA per nucleus may be closely correlated (*8*). We are, therefore, attempting to extend the correlation by making DNA measurements on species of known nuclear volume and radiosensitivity. From Table 1 and Fig. 2 it can be seen that our preliminary results indicate that the amount of DNA per nucleus is related to nuclear volume and radiosensitivity and that average DNA content per chromosome is also related to radiosensitivity in the species studied. Published values of DNA content (*9*, see Table 1) also show a reasonable correlation with average nuclear volume as determined in our laboratory. With decreasing nuclear volumes, that is, from the larger to the smaller volumes, there is a corresponding reduction in DNA content and in radiosensitivity. Much more extensive data are needed to establish the degree of correlation, but it seems highly probable that a general relationship may exist between average nuclear volume and average DNA content. There are certain exceptions—nuclear size and DNA content of a tissue or of a species do not always vary together (*10*)—but this should not invalidate the general concept.

The above correlations have been worked out with plant material. However, since plant and animal nuclei have so much in common, it seems highly probable that the same correlations will hold for some microorganisms and for some animal species as suggested by Puck (*11*). Certainly other factors are important, but DNA content and nuclear volume may also be correlated with differences in radiosensitivity of different cell types or different stages of development in animals as well as in plants (*12, 13*).

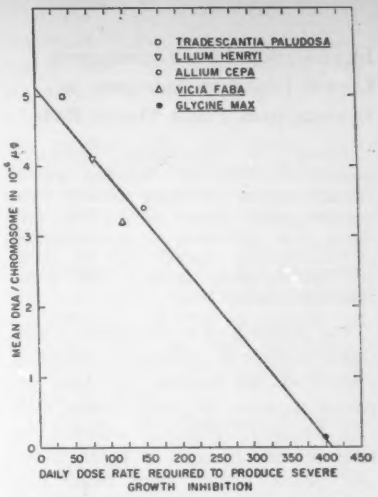


Fig. 2. Relationship between mean DNA values per chromosome and radiosensitivity in five species of plants.

ARNOLD H. SPARROW
JEROME P. MIKSCHE
Biology Department, Brookhaven National Laboratory, Upton, New York

References and Notes

1. A. Marshak, *Proc. Natl. Acad. Sci. U.S.* **23**, 362 (1937); G. Ostergren, R. Morris, T. Wakonig, *Hereditas* **44**, 1 (1958); N. Nybom, *Botan. Notiser* **109**, 1 (1956).
2. A. H. Sparrow and E. Christensen, *Science* **118**, 697 (1953).
3. A. H. Sparrow and J. E. Gunckel, *Proc. Intern. Conf. Peaceful Uses Atomic Energy, Geneva, 1955* **12**, 52 (1956); A. H. Sparrow and L. A. Schairer, *Proc. 2nd U.N. Intern. Conf. Peaceful Uses Atomic Energy, Geneva, 1958* **27**, 335 (1958).
4. A. H. Sparrow and J. P. Miksche, *Radiation Research* **12**, 474 (1960).
5. J. N. Davidson, S. C. Frazer, W. D. Hutchison, *Biochem. J.* **49**, 311 (1951).
6. K. Burton, *ibid.* **62**, 315 (1956).
7. A. H. Sparrow, R. L. Cuany, J. P. Miksche, L. A. Schairer, in *Proc. of Symp. on Effects of Ionizing Radiation on Seeds and Their Significance for Crop Improvement, 1960*, in press.
8. G. Hertwig, *Mikroskop.-Anat. Forsch.* **45**, 37 (1939).
9. E. Rasch and J. W. Woodard, *J. Biophys. Biochem. Cytol.* **6**, 263 (1959).
10. F. Schrader and C. Leuchtenberger, *Exptl. Cell Research* **1**, 421 (1950).
11. T. T. Puck, *Revs. Modern Phys.* **31**, 433 (1959).
12. A more thorough discussion of the theoretical aspects of the nuclear volume correlation and other factors affecting the responses of plants to radiation exposures is in press (*7*).
13. A portion of this investigation was carried out during the tenure of a postdoctoral fellowship (CF-10,708) to one of us (J.P.M.) from the National Cancer Institute, U.S. Public Health Service. We are indebted to L. A. Schairer, Anne Rogers, and Agnes Smith for their excellent technical assistance. The research was carried out at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission.

8 March 1961

Identification of a Cyanogenetic Growth-Inhibiting Substance in Extracts from Peach Flower Buds

Abstract. A cyanogenetic substance capable of completely inhibiting growth of pea sections has been isolated from dormant peach flower buds. This substance was identified as mandelonitrile (*dl*-benzaldehyde cyanohydrin) by infrared spectographic analysis and paper chromatography.

The presence of a cyanogenetic substance capable of completely inhibiting growth of pea sections has been reported to occur in peach flower buds (*1*). Recently, Jones (*2*) followed the level of total cyanide in peach leaves and peach flower buds from July through February. Total cyanide was found to increase rapidly, beginning about the time rest ended, and was highest in buds in the balloon stage. It was proposed that cyanide might be associated with rest in peach flower buds.

Earlier attempts by us to isolate and identify the cyanide compound resulted in failure, primarily because they were directed toward obtaining a sample of pure crystalline material. When it had been determined that the material was a liquid, it was isolated in a relatively pure form by the following method.

Dormant peach flower buds were collected and extracted for 24 hr in two changes of diethyl ether. The ether extracts were combined, and the ether was evaporated off at room temperature. The residue was then dissolved in ethyl acetate and filtered. The material left by the evaporation of the ethyl acetate was picked up in distilled water and filtered. The water fraction, which was extracted with diethyl ether in a separatory funnel, was discarded. Upon evaporation of the ether fraction, a yellow oily liquid remained, which had an odor similar to that of mandelonitrile.

On the assumption that this substance might be mandelonitrile (*dl*-benzaldehyde cyanohydrin), we obtained a sample of the latter, for comparison with the unknown substance, from the K & K Laboratories, Jamaica, N.Y.

The unknown material and mandelonitrile were chromatographed on Whatman No. 1 filter paper in a butanol, ethanol, water solvent (1:2:3). The unknown material had an R_F of 0.95, identical with that of mandelonitrile. Both the unknown material and mandelonitrile gave a rusty red color when the chromatograms were sprayed with sodium picrate solution. Both materials caused complete inhibition of growth of pea sections when the spots were cut out of the chromatogram and used in growth tests. As little as 10^{-8} mole of mandelonitrile was sufficient to completely inhibit growth of pea sections.

Mandelonitrile and the unknown substance were chromatographed in a hexane, ethanol, water solvent (1:1:2). The unknown material had an R_F of 0.78, identical with that of mandelonitrile.

Samples of the unknown material and of mandelonitrile were sent to Sadtler Research Laboratories, Philadelphia, for infrared examination. The spectrum of mandelonitrile and that of the unknown were very similar (Fig. 1). It was proposed that the differences in the spectra might be due to the presence of prunasin (*d*-mandelonitrile glucoside), a closely related compound. Spectographic analysis of a commercial sample of prunasin and of a mixture of prunasin and mandelonitrile indicated that the unknown sample sent in for analysis did contain a small quantity of prunasin. Prunasin is reported to be the first breakdown product of amygdalin, mandelonitrile being formed upon the hydrolysis of prunasin.

The results of these investigations indicate that the cyanogenetic growth-inhibiting substance isolated from peach flower buds is mandelonitrile, a powerful growth-inhibiting substance. To our knowledge, neither mandelonitrile nor prunasin has been previously reported to occur in peach flower buds (*3*).

M. B. JONES
J. V. ENZIE
New Mexico State University, University Park

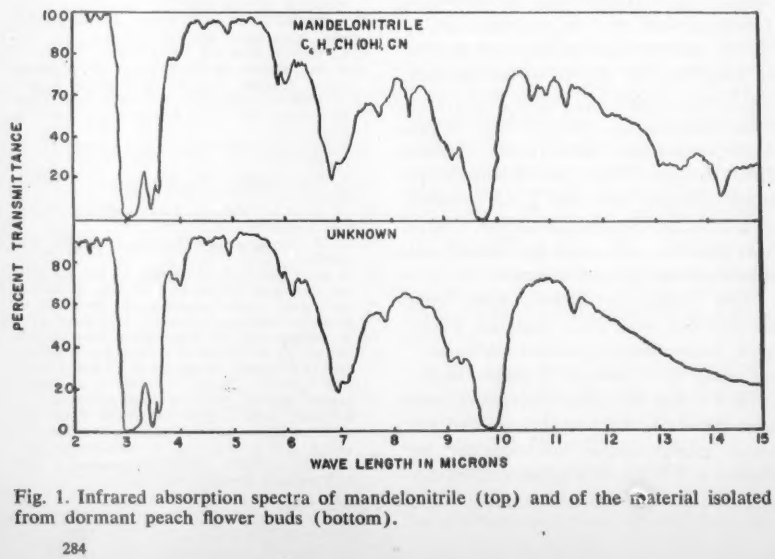


Fig. 1. Infrared absorption spectra of mandelonitrile (top) and of the material isolated from dormant peach flower buds (bottom).

References and Notes

1. M. B. Jones, J. W. Fleming, L. F. Bailey, *Proc. Am. Soc. Hort. Sci.* **69**, 152 (1957).
2. M. B. Jones, *ibid.*, in press.
3. This report is journal series No. 147 of the Agricultural Experiment Station, New Mexico State University.

3 April 1961

Reaction of Human Sera with Mammalian Chromosomes Shown by Fluorescent Antibody Technique

Abstract. Certain human sera, including sera from five patients with lupus erythematosus, react with mammalian chromosomes. If chromosomal preparations are exposed first to the serum and then to horse antihuman globulin conjugated with fluorescein, the chromosomes will fluoresce. Sera having this activity appear to react with all the chromosomes of the cell.

Sera from patients with certain diseases, particularly lupus erythematosus, react with the nuclei of human cells. When serum with antinuclear activity is incubated with human cells, gamma globulin from the serum reacts with the nuclei of the cells. If the cells are then incubated with rabbit or horse antihuman globulin, which has been conjugated with fluorescein, the nuclei will fluoresce under ultraviolet light (*1*). Sera from a number of patients with lupus erythematosus, Sjögren's syndrome, and several other diseases

Table 1. Nuclear fluorescence after treatment of cells with certain sera and staining with fluorescein-labeled horse antihuman globulin.

Lupus erythematosus	Nephrosis	Sjörgen's syndrome	Normal donors
Sera tested			
6	2	3	3
Sera positive against acetone-fixed mouse liver nuclei (1:8 dilution)			
6	2	3	0
Sera positive against ITA nuclei (chromosomal preparation)*			
5	1	0	0
Sera positive against CHA† nuclei (chromosomal preparation)			
5	1	0	0

* ITA, a strain of human euploid fibroblasts developed from skin of a normal donor. † CHA, a line of Chinese hamster fibroblasts (see text).

have been shown to possess this activity in high titer (*2*, *3*). In some cases, discernible antinuclear activity has been found at titers in excess of 1:4000. Antinuclear activity is uncommon in sera from normal donors and is very rare at titers greater than 1:8. A titer of 1:8 has therefore been arbitrarily designated as diagnositic of abnormal sera.

The antinuclear activity when present is demonstrable against the patient's own cells, cells from other donors, and other mammalian cells. The significance of this activity in the diseases in which it is commonly found is not fully understood. The activity may be related in some instances to the pathogenesis of the disease.

The material within the nucleus with which the serum reacts has been studied in the case of patients with lupus erythematosus. It would appear that the serum reacts with deoxyribonucleic acid and with nuclear histones (*4*). Some other nuclear antigens may also be involved.

Since the reaction is between the serum and the nucleus of the cell, and since it is histologically demonstrable, we have inquired whether the chromosomes are involved in the reaction. One might expect them to be, partly because of the character of the known antigens referred to above and partly because of the extent of the nuclear reactions—that is, the reaction is not confined to the nuclear membrane. We were particularly interested in the following questions.

1) In lupus erythematosus sera which have antinuclear activity, will the chromosomes fluoresce? If so, do all of them fluoresce, or some of them, or only certain segments?

2) Do sera from patients with Sjögren's syndrome and other diseases where antinuclear activity is sometimes present show the same pattern of chromosomal fluorescence as lupus erythematosus sera?

Sera from six patients with lupus erythematosus, three with Sjögren's syndrome, and two with nephrosis were used. All the sera had antinuclear activity, detectable at a dilution of at least 1:8 when tested by the fluorescent antibody technique with acetone-fixed mouse liver sections (*5*). Sera from three normal controls were also used. These sera had no detectable antinuclear activity when tested under the same conditions used for the abnormal sera.

Chromosomal preparations from two strains of euploid human fibroblasts and human peripheral blood from a normal donor were used. The lines were developed by the usual technique (*6*). In addition, an established line of Chinese hamster fibroblasts (*7*) and the S-3 subline (*8*) of the Hela group (*9*) were used. Chromosomal preparations of tissue culture cells were made by the technique of Tjio and Puck (*10*), and those of peripheral blood cells were prepared by the method of Moorhead *et al.* (*11*). After fixation and air drying of the cultured cells and mouse liver sections, the test sera were allowed to react with the preparations for 20 min and subsequently were stained with fluorescent antibody by the technique of Goodman *et al.* (*5*). The specimens were stimulated with ultraviolet light at wavelengths of 3900 to 4400 A and 3600 to 3700 A, and fluorescence photomicrographs were taken as described by Tobie (*12*).

In Table 1 the reactions of the undiluted sera used with the nuclei of two lines of cultured cells are given. Similar results were obtained with the other lines used and with peripheral blood cells in short-term culture. Note that although the sera from three patients with Sjögren's syndrome had antinuclear activity against acetone-fixed mouse liver cells, they did not react with the nuclei of the cultured cells (Carnoy-fixed).

The sera which did show antinuclear activity against the cultured cells appeared to react with all the chromo-

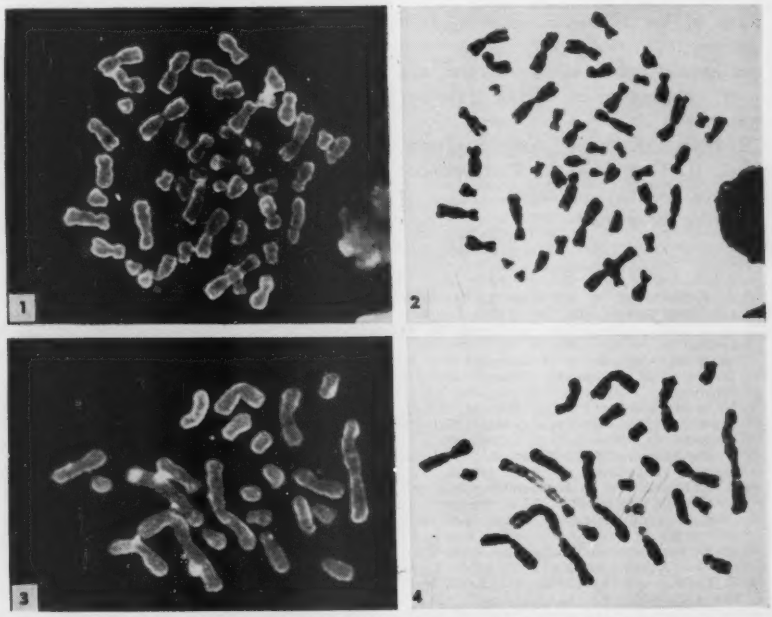


Fig. 1. Fluorescence photomicrograph of human chromosomes from peripheral blood culture stimulated with ultraviolet light (3900 to 4400 A). Chromosomes were treated with a dilution of a lupus erythematosus serum (1:50) and stained with fluorescein-labeled horse antihuman globulin. Fig. 2. Photomicrograph of the chromosomes in Fig. 1 taken with visible, white light; orcein stain. Fig. 3. Fluorescence photomicrograph of Chinese hamster chromosomes from tissue culture stimulated with ultraviolet light (3900 to 4400 A). Chromosomes were treated with a dilution of a lupus erythematosus serum (1:50) and stained with fluorescein-labeled horse antihuman globulin. Fig. 4. Photomicrograph of the chromosomes in Fig. 3 taken with visible, white light; orcein stain.

somes of the cells. When incubated first with these sera and then with horse antihuman globulin conjugated with fluorescein, the euploid fibroblasts and the peripheral blood cells (Fig. 1) showed 46 discrete fluorescent chromosomes. When, after fluorescent staining, the same cell was restained with acetic acid–orcein and photographed in visible light, every chromosome staining with fluorescent antibody also stained with orcein (Fig. 2). Similar results were obtained with the Chinese hamster line (Figs. 3 and 4). The sera from the normal donors, one patient with lupus erythematosus, one patient with nephrosis, and from the three patients with Sjögren's syndrome did not lead to any chromosomal fluorescence. Easily detectable chromosomal fluorescence was obtained with one lupus erythematosus serum at a dilution of 1:320.

These investigations suggest that certain human sera react with mammalian chromosomes and that, moreover, the reaction is with the full chromosomal complement of the cell. It may be of interest to see whether sera which are more specific in their chromosomal reactions can be found. It may also be useful to try to absorb some of the antinuclear activity with nuclear fractions or with nuclei from one species before incubating the sera with chromosomes from another species.

ROBERT S. KROOTH*, JOHN E. TOBIE, J. H. TJIO, HOWARD C. GOODMAN
National Institutes of Health, Bethesda, Maryland

References

1. E. J. Holborow, D. M. Weir, G. D. Johnson, *Brit. Med. J.* **II**, 732 (1957).
2. G. J. Friou, *Yale J. Biol. and Med.* **31**, 40 (1958).
3. W. R. M. Alexander, J. M. Bremmer, J. J. R. Duthie, *Ann. Rheumatic Diseases* **19**, 338 (1960).
4. H. R. Holman, H. R. G. Deicher, H. G. Kunkel, *Bull. N.Y. Acad. Med.* **35**, 409 (1959).
5. H. C. Goodman, J. L. Fahey, R. A. Malmgren, *J. Clin. Invest.* **39**, 1595 (1960).
6. R. S. Krooth and A. N. Weinberg, *J. Exptl. Med.* **113**, 1155 (1961); T. T. Puck, S. J. Ciecura, A. Robinson, *J. Exptl. Med.* **108**, 945 (1958).
7. D. K. Ford and G. Yerganian, *J. Natl. Cancer Inst.* **21**, 393 (1958).
8. T. T. Puck and H. W. Fisher, *J. Exptl. Med.* **104**, 427 (1956).
9. G. O. Gey, W. D. Coffman, M. T. Kubicek, *Cancer Research* **12**, 264 (1952).
10. J. H. Tjio and T. T. Puck, *J. Exptl. Med.* **108**, 259 (1958).
11. P. S. Moorhead, P. C. Nowell, W. T. Mellman, D. M. Battips, D. A. Hungerford, *Exptl. Cell Research* **20**, 613 (1960).
12. J. E. Tobie, *J. Histochem. and Cytochem.* **6**, 271 (1958).

* Present address: Department of Medicine, Strong-Rochester Municipal Hospital, Rochester, N.Y.

15 May 1961

Possible Mode of Antidepressive Action of Imipramine

Abstract. Imipramine augmented and prolonged methamphetamine-induced increases in the rate of responding of rats working for "rewarding" hypothalamic and midbrain stimulation. In contrast, chlorpromazine antagonized the effects of methamphetamine on self-stimulation. These opposite psychopharmacological effects are consistent with the different clinical effects of these drugs and suggest a mechanism for the antidepressive action of imipramine.

Despite the similarity between their chemical structures, imipramine and chlorpromazine differ in certain of their clinical actions. As a rule, chlorpromazine calms agitated patients, while imipramine elates depressed ones (*1*). Pharmacological tests have provided no basis as yet for the qualitative difference in these clinical actions. Most often, the same pattern of results is seen with the two drugs in the laboratory (*2*).

As a basis for our experiments, we have tentatively taken the view that agitations and depressions result from abnormalities in motivational and reward processes—agitation from pathological overactivity of reward processes (*3*), and depression from underactivity. On this view, it may be supposed that drugs effective against agitation inhibit an excessive reward activity, and that drugs effective against depression enhance a deficient reward activity.

The brain system that subserves these functions of motivation and reward has been made accessible to experimental investigation by the development of precise methods both for stimulating deep in the brain and for measuring changes in behavior. The self-stimulation technique, in which an intact and unanesthetized animal is trained to obtain brief electrical stimulations of its own brain by performing an arbitrary response (such as pressing a lever), is the method of choice for these studies (*4*). In this paper, we report the effects, and particularly the interactions, of imipramine, chlorpromazine, and amphetamine on self-stimulation.

Adult male rats were implanted with permanent bipolar platinum electrodes in the posterior hypothalamus or midbrain tegmentum. After they recovered, they were trained to stimulate their brains electrically by pressing a lever. Each response delivered a 0.15-sec current train of moderately rewarding intensity (about 0.4 ma). The stimulating wave form was a square pulse of 0.2-msec duration presented at 100 pulses per second through a cathode follower output stage and a shielded, low-impedance isolation transformer to the electrodes (*5*). These stimulating conditions are relatively noninjurious and thus allow the self-stimulation base lines to be stable for many months. With properly placed electrodes, the training often requires only a few minutes.

After the rats became expert at self-stimulation, the stimulating current was lowered individually for each rat, to a level in the vicinity of the threshold for self-stimulation (0.1 to 0.25 ma). Drug tests were begun after many sessions under the minimal current conditions, after the response rates had stabilized at a low level. At least one week intervened between drug dosings. All doses reported are expressed in terms of the total salt.

Our first experiments compared the effects of chlorpromazine and imipramine. The results were somewhat disappointing, as both drugs were found to inhibit self-stimulation. Chlorpromazine was about ten times more potent as an inhibitor than imipramine. These results coincided with published pharmacological findings.

We then learned of work of Carlton (*6*) who found that imipramine augments the facilitating action of amphetamine on conditioned avoidance behavior. We knew from earlier studies that amphetamine is a highly active agent in the self-stimulating test; specifically, it lowers the threshold for electrical reinforcement, indicating a facilitating action on structures of the reward system (*7*). We therefore set about to determine the effects of imipramine and chlorpromazine on the amphetamine or methamphetamine) response in the self-stimulation test.

Figure 1 summarizes our main findings. Six weekly sessions of self-stimulation performance under various drug conditions are depicted for a rat implanted in a reward area of the midbrain tegmentum. The depressed base line rate of self-stimulation generated by the threshold current intensity is seen in Fig. 1*A*. A small dose of *d*-methamphetamine hydrochloride (0.25 mg/kg) produced a clear increase in rate beginning about 15 min after the injection (Fig. 1*B*). The methamphetamine dose was carefully selected to provide a moderate, but unequivocal, effect. Pretreatment with 3 mg/kg of

chlorpromazine hydrochloride antagonized the facilitative effect of the methamphetamine on self-stimulation (Fig. 1*C*). In contrast, pretreatment with 5 mg/kg of imipramine hydrochloride greatly augmented the increase in the self-stimulation rate induced by methamphetamine. This dose of imipramine has no apparent effect of its own on self-stimulation. Greater augmentation is seen to result from a 15 mg/kg dose than from a 5 mg/kg dose (compare Figs. 1*D* and 1*E*). The latency of the methamphetamine response also was decreased by imipramine pretreatment; the effect on latency may be seen to be dependent on the dose of imipramine. These effects are extremely dependable; we have obtained imipramine potentiation of amphetamine effects more than 100 times with about 30 different animals in various follow-up experiments (*8*). Also interesting was the finding that chlorpromazine will antagonize the augmenting effect of imipramine on methamphetamine (compare Figs. 1*E* and 1*F*).

The present findings make it clear that imipramine does in fact favorably influence the activity of the brain system associated with reward, as we expected an antidepressant would. However, it seems to act in some indirect augmenting capacity (since amphetamine is required for the action) rather than through direct stimulation. This accords with the suggestion of Sigg (*2*) that imipramine exerts a "sensitizing" influence on central adrenergic synapses. All our data can be viewed as supporting this notion in the light of two considerations: (i) the work of Vogt showing that structures of the reward system have an unusually rich distribution of norepinephrine, and (ii) the suggestions of Brodie and Shore that amphetamine acts centrally by mimicking norepinephrine, and chlorpromazine acts centrally by blocking norepinephrine (*9*). Whether imipramine sensitizes directly, as has been postulated for cocaine, or indirectly, by the blockade of inhibiting influences, for example, remains a problem for future research (*10*).

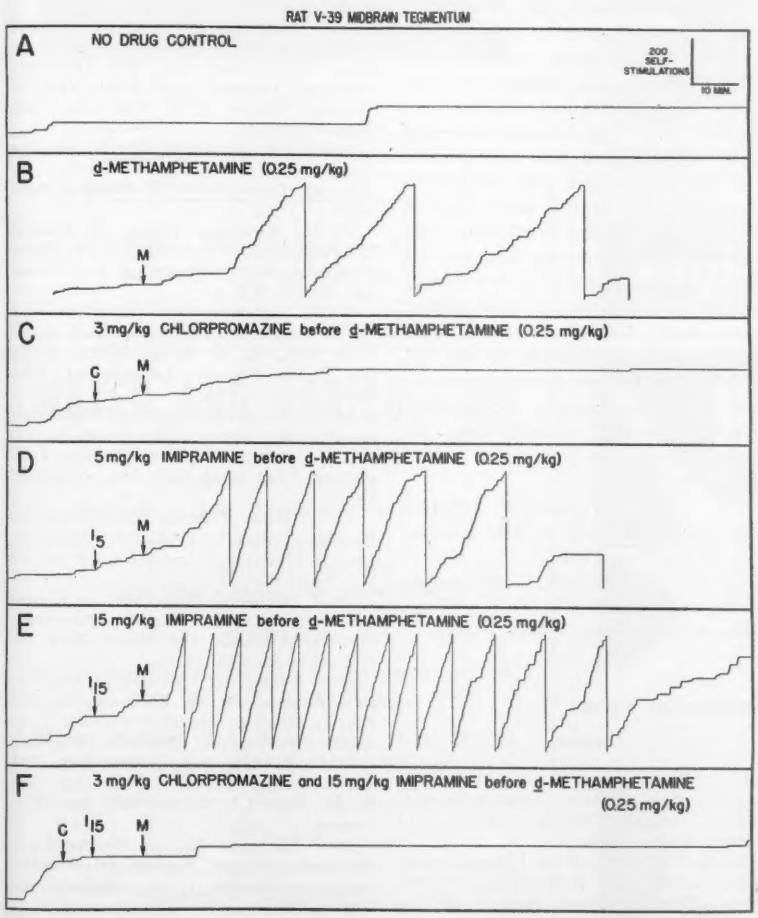


Fig. 1. Cumulative records of self-stimulation obtained from a representative rat with a midbrain electrode in six weekly experimental sessions. The different drug conditions are indicated. The arrows mark the time of the drug injections.

LARRY STEIN
JOSEPH SEIFTER

Basic Medical Sciences Research Division, Wyeth Laboratories, Philadelphia, Pennsylvania

References and Notes

1. R. Kuhn, *Am. J. Psychiat.* **115**, 459 (1958); H. E. Lehmann, D. H. Cohn, R. L. DeVerteuil, *Can. Psychiat. Assoc. J.* **3**, 155 (1958).
2. E. B. Sigg, *ibid.* **4**, 575 (1959); E. Costa, S. Garattini, L. Valzelli, *Experientia* **16**, 461 (1960).
3. J. Olds and R. P. Travis, *J. Pharmacol. Exptl. Therap.* **128**, 397 (1960).
4. J. Olds and P. Milner, *J. Comp. and Physiol. Psychol.* **47**, 419 (1954).
5. D. A. Brodie, O. M. Moreno, J. L. Malis, J. J. Boren, *Science* **131**, 929 (1960).
6. P. L. Carlton, *Pharmacologist* **2**, 70 (1960).
7. L. Stein and O. S. Ray, *Psychopharmacologia* **1**, 251 (1960).
8. The interactions between chlorpromazine and amphetamine are complex. In addition to its action of diminishing the magnitude of the amphetamine response, we have apparently paradoxical evidence that chlorpromazine also may prolong the duration of the amphetamine effect. Possibly this second action is related to the finding of W. R. Martin, J. L. Riehl, and K. R. Unna, *J. Pharmacol. Exptl. Therap.* **130**, 37 (1960), that chlorpromazine prolongs the pressor response to noradrenaline. This finding tempts one to view chlorpromazine and imipramine as belonging to the same psychopharmacological family. Both may be said to have an antidepressive action (seen as amphetamine potentiation or prolongation) at lower doses, and an ataractic action (seen as inhibition of self-stimulation) at higher doses. In imipramine, the antidepressive component is pronounced and well separated in dose from the ataractic component; in chlorpromazine, the ataractic component is pronounced and poorly separated, if at all, from the antidepressive component.
9. M. Vogt, *J. Physiol. (London)* **123**, 451 (1954); B. B. Brodie and P. A. Shore, *Ann. N.Y. Acad. Sci.* **66**, 631 (1957).

10. The technical assistance of Karey L. Sledge is gratefully acknowledged.

21 April 1961

Meetings

Marine Animal Sounds

Under the auspices of the biology branch of the U.S. Office of Naval Research, a conference was held on 30 and 31 March and 1 April at the Lerner Marine Laboratory, Bimini, Bahamas, a field station of the American Museum of Natural History, New York. The purpose was to acquaint interested scientists with the progress of a recently initiated study to determine the feasibility of obtaining information on marine animals in their natural environment by means of a hydrophone system. This project is being carried on by the Marine Laboratory, Institute of Marine Science, University of Miami, under the direction of John C. Steinberg.

There were 20 participants and guests at the conference. William N. Tavolga, of the American Museum of Natural History, served as chairman. Also present were James A. Oliver, director of the American Museum; Robert S. Mathewson, resident director of the Lerner Marine Laboratory; and Michael Lerner, founder of the laboratory. Representing the Marine Laboratory, Institute of Marine Science, University of Miami, were F. G. Walton Smith (director), Fritz Koczy, Steinberg, Warren J. Wisby, William C. Cummings, Morton Kronengold, Herbert Kumpf, and Joseph Richard. Attending from the Narragansett Marine Laboratory, University of Rhode Island, were Charles J. Fish (director) and Marie Poland Fish. From the Woods Hole Oceanographic Institution were Richard H. Backus and William E. Schevill. Representing the Office of Naval Research was Sidney R. Galler.

The system under consideration consists of two hydrophones located on the east bank of the Gulf Stream which are connected by cable to shore-based recording and analyzing equipment in the Lerner Marine Laboratory. The clarity of the waters around Bimini, the proximity of the Gulf Stream, and the presence of the laboratory led to the selection of this location. One hydrophone is on the bottom, a mile from shore, at a depth of 17 fathoms. The other is a mile farther out, at 200 fathoms. The equipment makes possible continuous monitoring of sounds over long periods of time.

Roars, knocks, honks, squeals, "popping of corks"—old sounds from new places—were heard in profusion from the ocean depths as scientists exchanged ideas and discussed new problems. It was the enthusiastic and unanimous consensus, even at this early stage in the operation of the installation, that sound-producing animals frequent the waters of the Bimini area in sufficient numbers to make the region of interest in the study of marine bioacoustics. It appears that investigations in the following categories are feasible: concurrent visual observations, experimental behavior studies, identification of sources of unknown sound, and studies of seasonal changes.

WILLIAM N. TAVOLGA
American Museum of Natural History, New York, New York
JOHN C. STEINBERG
Marine Laboratory, University of Miami, Miami, Florida

Forthcoming Events

August

23–1. Radioisotopes in the Biological Sciences, conf., Intern. Atomic Energy Agency, Vienna, Austria. (IAEA, 11 Kärtner Ring, Vienna 1)

24–26. Physiology of the Hippocampus, intern. colloquium, Montpellier, France. (Mme. Mineur, Centre National de la Recherche Scientifique, 13 Quai Anatole France, Paris 7)

26–1. Radiology, 10th intern. congr., Montreal, Canada. (C. B. Peirce, Suite 204, 1555 Summerhill, Montreal 25, Canada)

26–2. History of Science, 5th intern. congr., Ithaca, N.Y., and Philadelphia, Pa. (Secretary, 5th Intern. Congr. of the History of Science, Cornell Univ., Ithaca, N.Y.)

27–29. International Congr. of Group Psychotherapy, 3rd, Paris, France. (W. Warner, P.O. Box 819, Grand Central Station, New York 17)

27–29. Psychosomatic Aspects of Neoplastic Disease, 2nd annual conv., Paris, France. (L. L. LeShan, Intern. Psychosomatic Cancer Study Group, 144 E. 90 St., New York 28)

27–1. American Congr. of Physical Medicine and Rehabilitation, Cleveland, Ohio. (D. C. Augustin, 30 N. Michigan Ave., Chicago 2, Ill.)

27–1. American Inst. of Biological Sciences, annual, Lafayette, Ind. (J. R. Olive, AIBS, 2000 P St., NW, Washington 6)

27–1. Coordination Chemistry, 6th intern. conf., Detroit, Mich. (S. Kirschner, Dept. of Chemistry, Wayne State Univ., Detroit 2)

28–30. Mathematical Assoc. of America, Stillwater, Okla. (H. L. Alder, MAA, Univ. of California, Davis)

28–30. Oak Ridge Inst. of Nuclear Studies, 8th annual summer symp., Gatlinburg, Tenn. (Symposium Office, University Relations Division, Oak Ridge Inst. of Nuclear Studies, P.O. Box 117, Oak Ridge, Tenn.)

28–30. Scandinavian Symp. on Fat Rancidity, 3rd, Sandefjord, Norway. (E. Törnudd, Gaustadallen 30, Blindern, Norway)

28–31. American Assoc. of Clinical Chemists, natl., New York, N.Y. (B. Klein, Chemistry Dept., Kingsbridge V.A. Hospital, Bronx, N.Y.)

28–31, American Soc. for Pharmacology and Experimental Therapeutics, Rochester, N.Y. (K. H. Beyer, Merck, Sharp and Dohme Research Laboratories, West Point, Pa.)

28–31. Chemical Physics of Nonmetallic Crystals, intern. conf., Evanston, Ill. (O. C. Simpson, Argonne National Laboratory, 9700 South Cass Ave., Argonne, Ill.)

28–1. Heat Transfer Conf., intern., Boulder, Colo. (S. P. Kezios, American Soc. of Mechanical Engineers, 29 W. 39 St., New York 18)

28–1. Ionization Phenomena in Gases, 5th intern. conf., Munich, Germany. (Secretariat, Oskar von Miller Ring 18, P.O. 463, Munich 1)

28–1. Radioactive Metrology, symp., Oxford, England. (B. W. Robinson, Applied Physics Division, National Physical Laboratory, Teddington, Middlesex, England)

28–1. Rockets and Astronautics, 3rd intern. symp., Tokyo, Japan. (Japanese Rocket Soc., 1-3, Ginza-Nishi, Chuo-Ku, Tokyo)

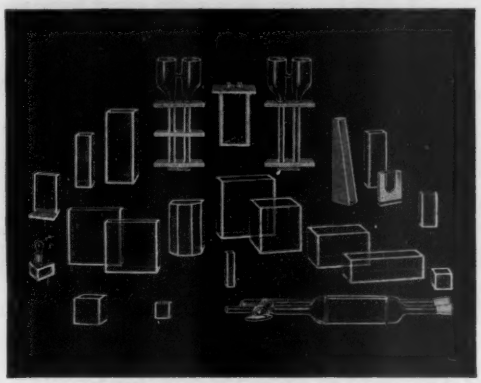
28–2. European Soc. of Haematology, 8th congr., Vienna, Austria. (H. Fleischhracker, Frankgasse 8, Billrothhaus, Vienna 9)

28–2. International Assoc. of Medical Laboratory Technologists, general assembly, Stockholm, Sweden. (Miss M. Westenins, Statens Bakteriologiska Laboratorium, Box 764, Stockholm 1)

28–2. Detonation Waves, intern. colloquium, Gif-sur-Yvette, France. (G. M. Ribaud, Centre National de la Recherche Scientifique, 13 Quai Anatole France, Paris 7, France)

(See issue of 21 July for comprehensive list)

GLASS ABSORPTION CELLS made by KLETT



SCIENTIFIC APPARATUS

Klett-Summerson Photoelectric Colorimeters—Colorimeters — Nephelometers — Fluorimeters—Bio-Colorimeters — Comparators — Glass Standards—Klett Reagents.

Klett Manufacturing Co.

179 East 87 Street, New York, New York

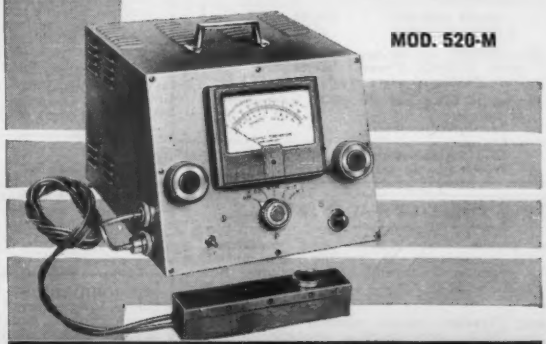
PHOTOVOLT

LINE-OPERATED
SUPER-SENSITIVE ELECTRONIC

MULTIPLIER-PHOTOMETER

For the exact measurements of extremely low light values down to 1/10,000 microlumen . . . for absorption and flame photometry. Colorimetry through microscopes. Scintillation measurements on crystals. Fluorescence trace analysis. Monochromatic color densitometry. Measuring high densities on micro areas. Light measurements through telescopes.

MOD. 520-M



Write for Bulletin #360 to

PHOTOVOLT Corporation

1115 Broadway • New York 10, N. Y.

WATER AND AGRICULTURE

A symposium presented at the AAAS Washington Meeting, December 1958. Published June 1960.

Roy D. Hockensmith, Editor
6 x 9, 206 pp., 21 illus., cloth
$5.00 AAAS members' cash orders, $4.50

CONTENTS

Water for the future: E. A. Ackerman, C. A. Davis, C. B. Brown, and R. L. Nace

Water sources: W. C. Ackermann, H. T. Orville, C. H. M. Van Bavel, and G. L. Barger

Water planning and use: C. H. Wadleigh, H. C. Storey, W. D. Criddle, and W. I. Palmer

Water control: T. W. Edminster, F. L. Timmons, D. L. Klingman, G. E. Harbeck, Jr., and C. B. Tanner

British agents: Bailey Bros. & Swinfen, Ltd. Hyde House, West Central Street London, W.C.1

American Association for the Advancement of Science
1515 Massachusetts Avenue, NW
Washington 5, D.C.

H^3 C^{14}

γ-Aminobutyric-1-C^{14} Acid
50 μc/$35 100 μc/$45

β-Alanine-1-C^{14}
50 μc/$30 100 μc/$38

CATALOG ON REQUEST

new england nuclear corp.

575 ALBANY STREET, BOSTON 18, MASS. HAncock 6-7311

PERSONNEL PLACEMENT

CLASSIFIED: Positions Wanted 25¢ per word, minimum charge $4. Use of Box Number counts as 10 additional words. Payment in advance is required.

COPY for ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Positions Open. Rates listed below—no charge for Box Number. Rates net. No agency commission. No cash discount. Minimum ad: 1 inch. Ads over 1 inch will be billed to the nearest quarter inch. Frequency rate will apply to only repeat of same ad. No copy changes. Payment in advance is required except where satisfactory credit has been established.

Single insertion	$40.00 per inch
4 times in 1 year	38.00 per inch

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS WANTED

Bacteriologist. B.S., M.S. 3 years' experience, 1 year commercial in vaccine development. Seeks commercial or institution position. Box 158, SCIENCE. X

Biology Teacher desires position in northern college. M.A.; now teaching zoology, botany, plant morphology; trained in zoology, ecology, conservation. Publications; references available. Daniel McKinley, 624 Hunter Avenue, Winston-Salem, North Carolina. 8/4

Clinical Microbiologist. M.S. Now associated with research institution. Desires position, supervise hospital microbiology laboratory. Metropolitan New York area. Box 159, SCIENCE.

POSITIONS OPEN

INFORMATION SCIENTIST

Our organization is actively engaged in the development of new methods for the dissemination and retrieval of scientific information. We offer an exceptional opportunity for a qualified man or woman on our CITATION INDEX PROJECT—a new approach to bibliographic control of scientific literature (See Science 122: 108-11, 1955). This full-time position carries the responsibility of supervising a staff of clerical and data processing personnel. The individual we are seeking may be a librarian or a scientist. He should have major experience in one or more of these areas: reference, cataloging, indexing, data processing. Send your complete resume including salary requirements to:

Institute for Scientific Information
Dept. S
33 So. 17th St. Phila., 3, Pa.

CHEMIST

(NATURAL PRODUCTS RESEARCH)

Unusual opportunity for Organic Chemist with M.S. or equal with interest in or experience with Natural Products (principally alkaloids) and the interrelationships of chemistry, botany and pharmacology. Evaluation of literature and laboratory data, close scientific contact with other members of team and organization, as well as foreign and domestic investigators. Ability to write clearly important. Excellent salary policy—broad benefits. Send complete résumé to:

S. M. FUESS
Smith Kline & French Laboratories
1518 Spring Garden Street
Philadelphia 1, Pa.
An Equal Opportunity Employer

POSITIONS OPEN

CHEMIST

With experience in isolation of drugs and toxic substances, for toxicology laboratory. Starting salary $6480; $6920 at end of first year, maximum at $7640. Paid hospital and medical insurance. Send résumé to B. Dearington, State Department of Health, State Office Building, Hartford, Conn.

ENDOCRINOLOGIST

Recent Ph.D., or some experience. Background and interests in biochemical aspects of steroids and other agents as related to hormonal action. New laboratories and opportunities for original research. Salary commensurate with qualifications.

Interested persons write to **Richard Cordell, Personnel Department, ABBOTT LABORATORIES, North Chicago, Illinois.**

M.S. in Chemistry interested in working for Ph.D. in biochemistry at University of Houston. Identification and purification of biologic immune factor anti-tumor agent applied toward research requirements. Salary $6000-$7000. Box 20065, Houston 25, Texas.

MICROBIOLOGIST III. Position with the Hawaii Department of Health's plague research project. Requires 3 years' experience in conducting bacteriological, parasitological, and serological laboratory tests and analyses and a master's degree with specialization in a biological or medical science. Salary: $6792–$8256 per annum. Write to Department of Personnel Services, 825 Mililani St., Honolulu 13, Hawaii.

UNIVERSITY LOVANIUM OF LEOPOLDVILLE

Applications are invited from candidates with doctors degree for appointment as lecturer in mathematics (lecturing in French language) to teach up to masters degree. Duties to commence in October 1961.
Salary scale, including overseas pay, $7,100 to $8,100 per annum. Free housing, medical care and insurance. Post is pensionable. Free passage, once each way for each tour of service for person appointed and wife; either passage allowance or maintenance allowance for children under 18. Tours of service: 9 months.
Write for further information (with curriculum vitae) to Rector L. Gillon, University Lovanium, B.P. 121, Leopoldville XI, Republique du Congo.

Applications are invited from candidates with doctors degree for appointment as lecturer in chemistry (lecturing in French language) to teach up to masters degree. Duties to commence in October 1961.
Salary scale, including overseas pay $7,100 to $8,100 per annum. Free housing, medical care insurance. Post is pensionable. Air passage and family allowance.
Write for further information (with curriculum vitae) to the President of the University, University Lovanium, B.P. 121, Leopoldville XI, Republique du Congo.

INVERTEBRATE ZOOLOGIST for 1961–62

Major responsibility would be a two-semester course in invertebrate zoology. Experience necessary. Rank probably assistant professor. Write directly to Chairman, Department of Biology,
University of Colorado
Boulder, Colorado

MEMORIAL UNIVERSITY OF NEWFOUNDLAND

St. John's, Newfoundland, Canada

Applications are invited for the position of Assistant Professor of Biology to give instruction primarily in Animal Physiology.

Candidates with background and experience in Marine Biology will receive preference. Ph.D. or equivalent essential. Duties beginning September 1961 to include teaching and research. The starting salary will be based on qualifications and experience.

Applications accompanied by complete curriculum vitae and the names of three references should be addressed to the Head, Department of Biology, Memorial University of Newfoundland.

The Market Place

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

DISPLAY: Insertions must be at least 1 inch in depth. Weekly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	$48.00 per inch
4 times in 1 year	44.00 per inch
13 times in 1 year	42.00 per inch
26 times in 1 year	40.00 per inch

PROOFS: If copy is to be set, and proofs submitted for approval, complete copy and cuts must be received 4 weeks in advance of publication date (Friday of each week); complete plates no later than 3 weeks in advance of publication date.

BOOKS AND MAGAZINES

Your sets and files of scientific journals

are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, CANNER'S, Inc. Boston 20, Massachusetts

SCIENTIFIC JOURNALS WANTED

Sets, Runs and Volumes bought at top prices. Your wants supplied from our Back Files of over 3,000,000 periodicals. **Abrahams Magazine Service N. Y. 3, N. Y.**

PROFESSIONAL SERVICES

CONSULTATION AND RESEARCH SINCE 1929

Food and Drug Research Laboratories
INCORPORATED
Toxicology • Pharmacology
Nutrition • Biochemistry • Bacteriology
BERNARD L. OSER, Ph.D., Director
Maurice Avenue at 59th Street
Maspeth 78, New York City
TWining 4-0800
WHERE EXPERIENCE COUNTS

SUPPLIES AND EQUIPMENT

YOU NEED THIS **FREE** CATALOG FOR YOUR FILES

Serums, antiserums and bloods of all kinds for technicians and tissue culture laboratories. No salesman will call.

COLORADO SERUM CO.
4950 York St. • MAin 3-5373 • Denver 16, Colo.

"From the hand of the veterinarian to research"®

albino rats
CHARLES RIVER *CD
(Caesarean derived)
CHARLES RIVER SD
(Sprague-Dawley descendants)
CHARLES RIVER W
(Wistar descendants)

HYPOPHYSECTOMIZED RATS

- Only Charles River CD animals used
- Rigidly controlled environment (same bldg.) birth to surgery.
- High speed surgery by graduate biologists.
- 10 years experience animal surgery.
- Overnight air service from Boston

* Trademark

THE CHARLES RIVER BREEDING LABS
1018 Beacon St., Brookline 46, Mass. RE. 4-2000
Henry L. Foster, D.V.M., President

APPLICATION FOR HOTEL RESERVATIONS

128th AAAS MEETING

Denver, 26–31 December 1961

The hotels for the AAAS Denver meeting have established special, low rates and have reserved appropriately large blocks of rooms for this meeting. Thus everyone making room reservations for the AAAS meeting is assured substantial savings.

The list of hotels and the reservation coupons below are for your convenience in making your hotel reservation in Denver. Please send your application, *not* to any hotel directly, but to the AAAS Housing Bureau in Denver and thereby avoid delay and confusion. The experienced Housing Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less.

If requested, the hotels will add a comfortable rollaway bed to any room, at $3.00 per night. Mail your application now to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival, and also probable date of departure.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

For a list of the headquarters of each participating society and section, see page 197, *Science*, 21 July. The Hilton is the AAAS headquarters hotel.

Rates for Rooms with Bath*

Hotel	Single for one	Double for two	Double for one	Twin Beds for one	Twin Beds for two	Studio Twins	Suites
Hilton	$8.50	$14.00	$10.00		$14.00	$15.00	$27.00 to $55.50
Brown Palace	8.00	13.00	9.00	$10.00	15.00		24.00 to 65.00
Cosmopolitan	8.50	13.00	9.00	10.00	14.00		25.00 to 60.00
Shirley Savoy		10.00	7.50	9.00	12.00		25.00 to 40.00

* All rooms are subject to a 2% Colorado State sales tax.

THIS IS YOUR HOUSING RESERVATION COUPON

AAAS Housing Bureau
225 West Colfax Avenue
Denver 2, Colorado

Date of Application .....

Please reserve the following accommodations for the 128th Meeting of the AAAS in Denver, 26–31 December 1961:

TYPE OF ACCOMMODATION DESIRED

Single Room ..... Double-Bedded Room ..... Twin-Bedded Room ..... Studio Twins .....

Suite ..... Desired Rate ..... Maximum Rate .....

Number in party ..... Sharing this room will be: .....

(Attach list if this space is insufficient. The name and address of each person, including yourself, must be listed.)

.....

.....

First Choice Hotel ..... **Second Choice Hotel** ..... **Third Choice Hotel** .....

DATE OF ARRIVAL ..... DEPARTURE DATE .....
(These must be indicated—add approximate hour, A.M. or P.M.)

NAME .....
(Individual requesting reservation) (Please print or type)

ADDRESS .....
(Street) (City and Zone) (State)

Mail this now to the Housing Bureau. **Rooms will be assigned and confirmed in order of receipt of reservation.**

Nuclear-Chicago's new family of liquid scintillation counters—

Just months old and already meeting the critical demands of exacting research

Although introduced and well received just last April, Nuclear-Chicago's new family of liquid scintillation counters is already hard at work. At varying levels of work load and within widely differing budgets, these three systems are setting new standards of precision, sensitivity and convenience for demanding scientists.

Research programs expand and equipment needs are upgraded. These new counting systems — compatible with your present, standard scaling instruments — easily accommodate to such growth.

Model 701 is a modestly priced, basic system for manual, room-temperature counting of limited numbers of samples. Uniquely sensitive detector assembly and advanced, transistorized circuitry provide high counting efficiency for carbon-14, tritium, and other soft-beta emitting isotopes. **Model 702** adds a precision-controlled low-temperature chamber for increased tritium-counting efficiency. The third member of the family, **Model 703,** provides fully automatic sample handling and varied options of readout.

Field conversion to upgrade Models 701 and 702 as work load and budget permit requires only the addition, first, of the custom-built, compact cooling chamber, and then, of the automatic sample changer mechanism.

Model 701 **Model 702** **Model 703**

Model 701—manual operation, shown with 8250 scaler

Model 702—manual, temperature-controlled operation, shown with 8250 scaler and 8600 timer

Model 703—automatic, temperature-controlled operation, shown with two 8250 scalers, 8600 timer and 8401 digital recorder

Please request literature on these integrated systems.

nuclear-chicago
CORPORATION

349 EAST HOWARD AVENUE, DES PLAINES, ILLINOIS